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INTRODUCTION.

During the summer of 1913 the Secretary of Agriculture established a board to reorganize the system of publications of the Department of Agriculture. In accordance with the proceedings of the board and the suggestions from representatives of the Weather Bureau, the "Bulletin of the Mount Weather Observatory" ceased to be published with the completion of its volume 6. Any subsequent contributions from the members of the research staff that would have been proper for that Bulletin will be incorporated in the Monthly Weather Review. The climatological service of the Weather Bureau will be maintained in all its essential features, but its publications, so far as they relate to purely local conditions, will be incorporated in the monthly reports for the respective States, Territories, and colonies.

Beginning with January, 1914, the material for the Monthly Weather Review will be prepared and classified in accordance with the following sections:

SECTION 1.—*Aerology*.—Data and discussions relative to the free atmosphere.

SECTION 2.—*General meteorology*.—Special contributions by any competent student bearing on any branch of meteorology and climatology, theoretical or otherwise.

SECTION 3.—*Forecasts and general conditions of the atmosphere*.

SECTION 4.—*Rivers and floods*.

SECTION 5.—*Bibliography*.—Recent additions to the Weather Bureau library; recent papers bearing on meteorology.

SECTION 6.—*Weather of the month*.—Summary of local weather conditions; climatological data from regular Weather Bureau stations; tables of accumulated and excessive precipitation; data furnished by the Canadian Meteorological Service; monthly charts Nos. 1, 2, 3, 4, 5, 6, 7, 8, the same as hitherto.

In general, appropriate officials will prepare the six sections above enumerated; but all students of atmospheres are cordially invited to contribute such additional articles as seem to be of value.

The voluminous tables of data and text relative to local climatological conditions that during recent years have been prepared by the 12 respective "district editors," will be omitted from the MONTHLY WEATHER REVIEW but will in future be collected and published by States at selected section centers.

The data needed in Section 6 can only be collected and prepared several weeks after the close of the month whose name appears on the title-page; hence the Review as a whole can only issue from the press within about eight weeks from the end of that month.

It is hoped that the meteorological data hitherto contributed by numerous independent services will continue as in the past. Our thanks are especially due to the directors and superintendents of the following:

The Meteorological Service of the Dominion of Canada.

The Central Meteorological and Magnetic Observatory of Mexico.

The Director General of Mexican Telegraphs.

The Meteorological Service of Cuba.

The Meteorological Observatory of Belen College, Habana.

The Government Meteorological Office of Jamaica.

The Meteorological Service of the Azores.

The Meteorological Office, London.

The Danish Meteorological Institute.

The Physical Central Observatory, Petrograd.

The Philippine Weather Bureau.

The General Superintendent United States Life-Saving Service.

SECTION I.—AEROLOGY.

REMARKS ON THE NATURE OF CYCLONES AND ANTI-CYCLONES.

[Communicated to the International Meteorological Congress at Chicago, Ill., August, 1893.]¹

By Prof. Dr. JULIUS HANN, Director.

[Dated: K.k. Zentralanstalt für Meteorologie und Erdmagnetismus, Vienna, May, 1893.]

[Those not already familiar with the "convection theory" of the origin and maintenance of cyclones and other whirling storms as set up by Espy and Ferrel, will find it expounded in the MONTHLY WEATHER REVIEW, April, 1906, 34: 164-165.—C. A.]

A distinguished American meteorologist, *William Ferrel*, has devised and developed the foundation of a theory of cyclones. It gives me pleasure to know that it was my privilege (1) to be the first to make Ferrel's theory generally known in Europe in the German language. This theory deals principally with the laws of the movement of the atmosphere in the complete well-developed cyclone; the origin of cyclones, i. e., the source of the energy needed for the movement of the air in the cyclone is treated but incidentally or not at all in Ferrel's first memoirs. Subsequently, Ferrel introduces Espy's views to explain the origin of the cyclone and in the last years of his life he almost passionately defended the so-called "convection theory" of cyclones although, so far as I can judge, it lay far from his original ideas which were based upon the general circulation of the atmosphere for the theory of which we also have to thank him.

The "convective theory" of cyclones, especially as presented by Reye (2) made on me also at first a great impression that one can indeed hardly escape from. By it a large group of phenomena is referred back to simple physical laws so clearly that one experiences a lively sense of satisfaction well expressed by Ferrel when he calls the "convection theory" a very beautiful and satisfactory theory.

But after the first incisive impression of this theory has given place to a more quiet consideration, and as soon as one turns to the facts and inquires how they harmonize with the theory, he soon finds that the totality of the phenomena of our whirlwind storms is not to be brought into conformity with the "convection theory." The great cyclones of the tropical oceans seem in most cases to find a satisfactory explanation in the "convection theory," as indeed a thorough study of the cyclones of the Bay of Bengal has led the most accurate of the new students of these storms, Blanford and Eliot, to be its enthusiastic advocates. As regards the origin of these cyclones, however, I can not share in the views of these prominent investigators, as I have expressly stated in the *Zeitschrift für Meteorologie* (3) where I have expounded certain views as to the origin of the cyclones of the Bay of Bengal based directly upon the admirable works of these Indian meteorologists.

The meteorologists of India, as is well known, have arrived at the opinion that agrees with the principle first developed by Espy and subsequently adopted by

Loomis, Buchan, Mohn, etc., that the cyclones of the Bay of Bengal owe both their origin and their continuance to the process of condensation and the precipitations that accompany them.

As opposed to the idea that precipitation can produce barometric minima I have, immediately on the appearance of Reye's book, set forth the most serious and, as it seemed to me, most important objections (4). In fact all phenomena when they are examined impartially, as well as theory itself, speak against the origination of a barometric depression by precipitation. Even so active a defender of the so-called "condensation theory" as Mr. Eliot could not refrain from the remark that the immense summer precipitation at Cherrapunjee seems to have no influence on the pressure, that indeed the effect of the heaviest rainfalls is in general rather an increase than a decrease of the atmospheric pressure (5), exactly as I have already demonstrated (6) for Batavia, Java. In regions near the Equator where, on account of the absence of the deflection of air currents by the earth's rotation, no great atmospheric whirl can arise, the heaviest and most extensive precipitation remains without any influence on the barometric pressure. If no great atmospheric whirls exist then there is no local deep barometric depression. In one of his first pioneer works Ferrel pointed out that the mean value of the nonperiodic barometric fluctuations increases with the geographic latitude and in fact nearly in proportion to the square of the latitude, while the deflecting force of the earth's rotation is proportional to the sine of the latitude. Ferrel (7) showed that the observations agreed very well with this theory. The deep depressions in the storm areas are a consequence of the whirling movement of the mass of air and *not* of the precipitation that occurs as a part of the train of phenomena of the whirl. No one has demonstrated this more clearly than Ferrel himself. The fact that the whirl and the barometric depression caused by it, are almost invariably connected with more or less abundant precipitation, is the natural consequence of the ascending movement of the air in the whirl. Wherever air ascends it cools and the associated aqueous vapor is partially condensed, this is one of the simplest results of generally known physical laws. Therefore, where large whirls arise a tendency to precipitation must occur. To conclude that cyclones, especially those of the tropics, arise from the accompanying heavy precipitation, that the latter is the cause of the barometric depression and of the whirl itself, is therefore an evident confusion of the effect with the cause.

In order to avoid misconceptions and to protect myself against the suspicion of adopting a narrow standpoint, I would right here remark that in my opinion, also, the precipitations that are introduced [into the depression] by the ascending whirls of air favor and further the maintenance and partly also the increase of the ascending movement of the atmosphere in the whirl. Since in consequence of the condensation of aqueous vapor and the latent heat thereby set free in ascending masses of moist air, the dynamic cooling is diminished, therefore the ascensional force of the masses of air in the interior of the whirl is assisted and the eventual lateral overhead

¹ This paper was written in May, 1893. It was translated by the Editor and prepared for publication in December, 1901, but has been delayed for the reasons stated in this REVIEW, February, 1914, 42: 93.

outflow of the ascended air is made easier. This favors the continuation of the whirling movement when it is once established.

The "convection theory" of cyclones places the fundamental conditions of their existence in the lower strata of air, by whose relatively high temperature and large content of aqueous vapor the ascending movement is started. Then the latent heat of condensed aqueous vapor and the deflecting force of the earth's rotation come into play and carry the work further. The "convection theory" seeks the cause of the origin as well as the direction of progress of cyclones principally in local conditions, in the characteristics of the lower strata of air at or near the earth's surface.

If we transfer the fundamental originating conditions of vortices to the upper strata of the air—as frequently has been done of late by defenders of this theory because it is no longer possible to ignore the convincing force of the facts and considerations against the origination of whirls in the lower strata—then in fact the "convection theory" of storms is fundamentally abandoned.

If, with Ferrel in his latest publications, we locate the seat of the cyclone at an altitude of about two miles or 3,200 meters (8) then [we remark that] all the physical bases of the "convection theory" fail at this altitude. At a temperature of about -10° or -20° C., such as prevails at this altitude, especially in winter when the cyclones are most frequent and intense, and in middle latitudes (say 40° in the United States and 48° in Europe), even air saturated with aqueous vapor contains but 1 or 2 grams of aqueous vapor per cubic meter, and the rate of diminution of temperature with altitude in this mass when it is ascending can scarcely be distinguished from that of dry air. The vertical temperature gradient even at the beginning of the ascent amounts to 0.8° C. or 0.9° C. per hundred meters, whereas, even in perfectly dry air, as is well known, it amounts to about 1° C. per 100 meters. If now the air has ascended but 2,000 meters in the whirl then it must have cooled to -36° or -40° C. and its aqueous vapor has practically all condensed. Therefore a whirlwind corresponding to the "convection theory" formed even under the most favorable conditions at such altitudes as 3 kilometers or more, can attain no considerable intensity and in no way have the power that Ferrel assumes, to pump up the lower cold air strata 3,000 meters deep, by its suction or to set them in rotation by means of friction. Even in the moist, warm, marine climate of England's summer, according to Glaisher's balloon observations, the quantity of aqueous vapor in the air at altitudes of 6 or 7 kilometers is infinitesimal.

Therefore the "convection theory" of cyclones is forced to locate the place of origin and development of the great atmospheric whirl in the lowest strata of the atmosphere, because these alone hold so great a quantity of aqueous vapor that by its condensation the dynamic cooling of the ascending air in the whirl is so far diminished that one may suspect that the whirling mass of air has a higher mean temperature than that of the surrounding atmosphere. For this latter condition is a necessary assumption of the "convection theory." The mass of air in the cyclone must to a certain extent have a higher temperature than its surroundings; it must experience an uplift [due to buoyancy]. This assumption is certainly best fulfilled by the great cyclones of the Tropics, for example, by those of the Bay of Bengal that originate during the transition period from one monsoon to the other. In the cyclones of middle and higher latitudes this assumption seems to be inappropriate; at least it does not appear so regularly and to such an extent as that a theory of

cyclones can be based upon it. The cyclones of the Bay of Bengal, that occur about the time of the change of monsoons (May and October) may originate in the lower atmospheric strata. The two following circumstances favor this view. These cyclones form above the Indian Ocean, generally in the southeastern part of the Bay of Bengal and dissolve rapidly as soon as they reach the land. This characterizes them as formations that are located principally in the lower strata of the atmosphere. In support of Faye's theory of waterspouts and tornados, Hirn very properly calls attention to the difficulty of assuming that powerful whirls arise in the lower layers where the movement of air once initiated toward a center is greatly enfeebled and will certainly soon be destroyed by friction even before an intensive whirl can be formed. For it is only when large masses of air are drawn from a distance into the whirling movement that a powerful whirl can develop in a previously quiet atmosphere. But this is not properly conceivable in the lower strata of the atmosphere above land surfaces, although one may without serious contradiction assume it for the cyclones of the Bay of Bengal. The whirls of the "convection theory" must break up and dissolve when they encounter high mountains, both for mechanical reasons and because they derive their source of energy from the lower strata of the atmosphere, but lose their vital principle in the higher, cold, vaporless strata. Precisely this does occur with the great cyclones of the Bay of Bengal; they generally come to an end as soon as they reach the land, and notwithstanding their extraordinary intensity are unable to pass over even the relatively low mountain chains of the Ghats, the Tipperary Hills, etc. In this respect these cyclones in fact show properties that we must assume to characterize the whirls of the "convection theory."

The cyclones of the season of the southwest monsoons, on the contrary, are of much feebler intensity, but pass entirely across southern India and show all the characteristics of the whirlwinds of higher latitudes, as clearly follows from the thorough investigations of John Eliot (9). In the upper strata there occur whirls that move with the general currents of the air and that certainly can not be explained as to their origin and nature by the "convection theory" alone. These are, like the cyclones of our latitudes, whirls in a general great air current from which they derive the principal part of their energy and which in general determines their progressive movement. Of course the "convection theory" has a part to play in this process, as indeed could not be otherwise in consideration of the high temperature and the abundance of vapor in the atmosphere in these latitudes and the season of the year (June and July).

The fact that the cyclonic storms of middle and higher latitudes frequently pass unhindered over mountain ranges several thousand meters high proves that, in these cases at least, the true seat of the atmospheric whirl is to be sought at far greater altitudes. At such altitudes, however, the "convection theory," as before explained, loses its applicability, since the physical forces themselves on which it is based can no more be effective.

In general, the method of progression of the large atmospheric whirls is in contradiction to the "convection theory," which demands a much greater dependence on the local meteorological conditions than is actually the case. The direction of progress of the whirl shows a much greater dependence on the general air currents in the upper strata of the atmosphere than on the temperature and moisture conditions of the lower strata of air. The "convection theory" must needs attach great weight to the rapid vertical temperature decrease in the regions

frequented by the paths of cyclone centers. A more or less unstable vertical equilibrium in the atmosphere extraordinarily favors the continuance and intensity of the whirls of the "convection theory." But in those regions over which they move these whirls strive to restore the stability of the vertical equilibrium in the atmosphere; the lower air strata are cooled, the higher strata warmed, the differences of temperature between the upper and lower are diminished. At the same time the aqueous vapor of the lower strata is condensed, the potential energy accumulated in the heat of the higher strata and in the greater vapor content of the lower strata is used up, and a new precipitation can not be at once initiated simply by ascending convection currents. Therefore cyclones of the "convection theory" must either avoid advancing over those portions of the earth's surface where a cyclone was active shortly before, or they must dissolve there.

Now, in fact, the smaller whirls that give rise to the so-called heat thunderstorms of the European summer do show this peculiarity and thereby they show themselves to be phenomena to which the pure "convection theory" may find full application. On the other hand, the greater atmospheric storms have the peculiarity of readily following at short intervals along the same path. They not only do not avoid the path of the preceding whirl but they favor it. This fact has already frequently been demonstrated. Even Doberck in his "Law of Storms in the Eastern Seas" says: "It is a well-known fact that barometric depressions are drawn toward those regions over which another depression has just passed." Now, this latter peculiarity of the greater atmospheric whirls is in complete contradiction to the "convection theory." Rather does this fact show that this theory plays only a subordinate role in the mechanism of these whirls and that the forces upon which the greater atmospheric whirls depend primarily for their origin and progress are not to be sought for *within* but *outside* of these whirls. This peculiarity undoubtedly indicates that it is the general relation of the distribution of atmospheric pressure and the disturbances in the general atmospheric circulation, to which the origin and the progression of our storm whirls must be attributed.

An additional fact that stands in notable contradiction to the "convection theory" explanation of our storms is the annual periodicity of the frequency and intensity of the extratropical cyclones. If the "convection theory" were really applicable to the majority of extratropical cyclones, then they should attain their maximum frequency and intensity in the summer season—but the facts are directly opposite to this. How can the "convection theory" explain that these storms attain their greatest intensity and frequency in the winter half of the year, in that season when the conditions of both origin and continuance are of all others most unfavorable? In winter the vapor-content of the air is very small and the vertical thermal equilibrium of the atmosphere extremely stable. Over the continents the lower strata of air are, at that season, not infrequently colder than the strata above—the temperature increases upward. The vertical temperature decrease is slower than in ascending air currents, even when these become saturated with aqueous vapor by the lowering of the temperature. Ascending masses of air, therefore, experience no uplift by reason of colder surroundings. How can one assume that under such conditions the atmospheric whirls of the "convection theory" can penetrate to the interior of Siberia where the aqueous vapor in the air is reduced to almost absolutely nothing at atmospheric temperatures of -30° to -40° C.?

And why are the great atmospheric whirls relatively rare and much less intensive in summer, when every condition for their origin and continuance is so much more favorable, if they really can be explained by the "convection theory"? The fact that in the course of their annual periodicity cyclones attain their maximum of frequency and intensity in the winter season, does therefore stand in very decided contradiction to the "convection theory" of storms.

On the other hand, this fact is in complete agreement with the view that the great atmospheric whirls derive their existence and their energy from the upper general currents of air which control the circulation of the atmosphere between the equatorial and the polar regions. The energy of these upper air currents is greatest in the winter season when both the temperature gradient and the barometric gradient of the upper and uppermost atmospheric strata between the Equator and the poles are greatest. Ferrel has shown that in the Northern Hemisphere the temperature gradient between the pole and the Equator is twice as great in January as in July; and that the corresponding upper west-to-east current must theoretically have from 2 to 4 times greater velocity in winter than in summer.

Therefore, when we assume that the great atmospheric whirls are to be considered as disturbances, so to speak, in the great currents circulating between the Equator and the poles or are dissolved by them, we at once explain the annual period of their frequency and intensity. The upper-air poleward pressure gradient is much steeper in winter and causes a much stronger atmospheric circulation. Therefore, if disturbances of the dynamic equilibrium occur, the forces thereby respectively annulled or roused to action must be much more powerful in winter than in summer. Möller has shown most thoroughly (10) that the rapidly moving upper layers of air must frequently produce a condition of unstable dynamic equilibrium that then leads to the formation of cyclones and anticyclones.

The movement of fluids in streams never goes on as "steady motion" but always partially resolves itself into whirls. *It is certainly not to be imagined that the powerful and rapid upper currents of air should flow from the Equator to the pole without the formation of whirls.* Helmholtz, also, has suggested that the reason why extraordinarily great velocities, such as the masses of air flowing from the Equator to the pole must attain in the higher latitudes according to the law of conservation of areas, actually do not appear, is to be sought in the fact that vortices must arise which absorb or dissipate a great part of the energy. Therefore the source of the energy of our storms need not be the first thing to be sought after.

If, now, many other facts also show that the atmospheric whirlwinds of the middle and higher latitudes must originate in the upper layers of the atmosphere, and if we note how simply the phenomena observed in the storms of our latitudes can be explained when we refer them back to their origin—then it is certainly not evident why we do not drop the useless effort to explain them by the "convection theory" and apply the latter to those phenomena only that it actually can most naturally explain.

In most recent times [i. e. about 1893] another class of observations has come to join the previous array of facts that testify most decidedly against the explanation of the storms of our latitude by the "convection theory." I mention this class in the last place intentionally, in order to show that the "convection theory" of the cyclones of middle and higher latitudes can not be saved even by the attempt to deny the importance of these observations.

Moreover these facts are of higher interest because they show the most beautiful agreement with the physical theory of cyclones.

It is well known that all observations agree in showing that in cyclones the air is ascending while in anticyclones, on the contrary, a descending current prevails. Cyclones and anticyclones are the two members of the vertical circulation of the atmosphere. In the ascending current of the cyclones there occurs dynamic cooling. In this process the aqueous vapor is condensed at a certain altitude, and this diminishes the rate of cooling in the ascending masses of air. The rate of the cooling, in the adiabatic expansion of moist air, lies between the limits 0.5° and 0.9°C. per 100 meters in our latitude. On the other hand, in the descending branch of the vertical circulation the air warms up and therefore can not form any precipitation; on the contrary, the air becomes relatively very dry. The rate of increase of temperature in descending air amounts to about 1°C. per 100 meters. If, therefore, we assume a closed vertical circulation of air in cyclones and anticyclones, such that the air ascending in the cyclone again sinks to the earth in the surrounding region, then theory shows that in the ring of descending air with high pressure at the earth's surface, the temperature of the air is higher than in the ascending current of the cyclone with a barometric depression at the earth's surface. Such formations can, of course, only be produced dynamically, in consequence of the general circulatory currents between the pole and the Equator, or generally in the general currents of air of greater extent and energy, as for example within the monsoon winds.

The "convection theory," on the contrary, assumes that the mass of air constituting a cyclone has a higher average temperature than the air in its neighborhood. It is precisely the buoyancy experienced by the specifically lighter warmer air in the ascending whirl that alone explains the origin and continuance of the cyclone according to the "convection theory."

Therefore the observations of temperature up to great altitudes in the region of cyclones and anticyclones should decide whether the cyclone and the anticyclone are at least in part purely dynamic formations or can be explained by the "convection theory."

The temperatures registered at the higher mountain stations in the Alps, on the Pic du Midi, etc., have recently made it highly probable that the great mass of air in the cyclone, at least up to altitudes of 3 or 4 kilometers, actually has a lower temperature than the air mass of the anticyclone (11). This fact speaks decidedly against the "convection theory," but stands in complete accord with the theory that ascending currents of air in general must have a lower temperature than the descending masses as in the anticyclone.

Although these observations hold good directly only up to 3 or 4 kilometers in altitude, still the absence of observations from greater altitudes does not favor the defenders of the "convection theory." The whirls of this theory must draw their energy from the lower layers of air that are richer in moisture; the theory has no longer any application at altitudes of 4 kilometers or more, because the whirls of the "convection theory" are well nigh impossible in this region of little vapor.

As to the temperature that prevails at very great heights (above 3 or 4 kilometers) in the descending masses of air of the anticyclones, this can only be decided by observations in balloon ascensions. Theoretically, this descending air warms at the rapid rate of 1°C. per 100 meters, but the actual temperature of the air

depends upon how rapidly the process of descent takes place and how great is the corresponding loss of heat by radiation. Cleveland Abbe (12) has given very interesting computations and conclusions on this point, but the temperatures determined by direct observations in anticyclones up to altitudes of 4 kilometers are more decisive in reference to the theory of cyclones.

Moreover, the ascending air within the cyclones experiences a very considerable cooling in contrast with the computed theoretical rate of vertical temperature decrease. This is the cooling due to the falling products of condensation, namely, the rain, hail, and snow. This lowering of the temperature of the body of air of cyclones by the falling rain and snow is very important. In the barometric Low of July 12, 1890, that moved from the Gulf of Genoa northeastward and partly over the Alps, the air was so greatly cooled that thick snowfall prevailed down to an altitude of 600 meters above sea level and the temperature at altitudes of 400 to 500 meters fell to 4° or 5°C. , and this in the middle of July. At an altitude of 3,100 meters the temperature was -5.3° , or about 6° below the average. It appears to me very probable that the air ascending in the region of cyclonic precipitation is cooled by the falling products of condensation more than the air descending in the anticyclones is cooled by the radiation of heat.

I may finally refer to (13) my "Remarks on the Temperature in Cyclones and Anticyclones;" also to my "Studies on the Temperature and Pressure of the Air on the Summit of the Sonnblick."

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- (7) Ferrel, W. in *Amer. jour. sci.*, New Haven, Conn., Nov., 1874, (5) 8; and Jan. 1861, (2) 31.
- (8) Möller, in order to more surely overcome certain difficulties, thinks this altitude might be increased to 5 or 10 kilometers.
- (9) Eliot, John. Account of the southwest monsoon storms generated in the Bay of Bengal during the years 1877 to 1881. *Indian met'l. mem.*, Calcutta, 1885, 2, pt. 6. See particularly p. 437, fig.
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- (13) I first demonstrated the relatively high temperature of the air in the region of the anticyclones in my memoir "Ueber das Luftdruck Maximum vom Januar, 1876." *Met. Ztschr.*, Wien, 1876, 11: 129, fig.
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HALOS AND PRECIPITATION AT WAUSEON, OHIO.

By J. M. KIRK, Local Forecaster.

[Dated Weather Bureau, Columbus, Ohio, Nov. 16, 1914.]

A summary of the record of halos observed and with it the percentage of halos that were followed by precipitation within 24 hours has been furnished by Mr. Thomas Mikesell, cooperative observer at Wauseon, Ohio. For this report he has used the 40-year period from 1873 to 1912, inclusive. During those 40 years a total of 2,918 halos were observed, or an average of 73 per year. Of these, 2,219 were solar and 699 were lunar halos. The greatest number observed in any one year was 109 in 1899 and the least, 40, in 1880.

The number of halos observed by months was as follows:

Month.	Solar.	Lunar.	Total.
January.....	171	97	268
February.....	215	74	289
March.....	294	78	372
April.....	293	74	367
May.....	276	55	331
June.....	204	41	245
July.....	130	17	147
August.....	110	17	127
September.....	96	35	131
October.....	139	55	194
November.....	145	77	222
December.....	146	79	225

Studying this record in connection with storms it was found that 58 per cent of the solar halos and 59 per cent of the lunar halos were followed by precipitation within 24 hours.

Studying the record in connection with barometer readings and storms the following interesting relations were found:

Condition of barometer.	Number of halos observed.	Percentage of halos followed by precipitation within 24 hours.	Percentage of halos not followed by precipitation within 24 hours.
Above normal and rising....	220	37	63
At about highest point.....	495	42	58
High but falling.....	893	64	36
About normal.....	572	58	42
Below normal and falling....	334	83	17
Near the lowest point.....	205	66	34
Low but rising.....	199	53	47

By months the records shows the following relations:

Months.	Percentage of halos followed by precipitation within 24 hours.	Percentage of halos not followed by precipitation within 24 hours.
January.....	61	39
February.....	60	40
March.....	58	42
April.....	62	38
May.....	57	43
June.....	49	51
July.....	56	44
August.....	59	41
September.....	55	45
October.....	50	50
November.....	63	37
December.....	65	35

This record shows a greater frequency of halos in winter and spring than in summer and fall, and when the barometer is falling rather than when it is rising. With a low and falling barometer the chances for precipitation following the observance of a halo are in the ratio of 5 to 1,

but with a high or rising barometer the probabilities are against precipitation within the following 24 hours.

Mr. Mikesell states that by extending the time limit to 30 hours the number of halos observed that were followed by precipitation was increased about 8 or 10 per cent.

LIGHT PILLARS AT BERNE, IND.

The Weather Bureau cooperative observer at Berne, Ind., Mr. H. M. Reusser, writes under date of December 18, 1914, as follows:

DEAR SIR: I wish to report an extraordinary phenomenon of the sun and our atmosphere this morning from a little before 7 a. m. to 7:30 a. m. I also send two poor drawings [omitted] of the same as seen in stages 1 and 2.

Before the sun rose we could see a bright reddish (not prismatic) streak nearly as wide as the sun's disk, extend straight up to about 20° to 25°, fading away and resembling the effects of a powerful search-light at night. Soon, or exactly at 7 a. m. the sun rose as a dark red ball, and as it rose above the horizon the streak was separated from the sun about 1°. As the sun rose higher it passed behind a small cloud and at that time the streak extended below the sun to about 3°. Finally, about 7:30 a. m., the sun passed behind the clouds and the wonder was past. Everybody that saw it said that this was the first of its kind ever seen by them and many asked me what the cause might be.

It is evident that Mr. Reusser describes an occurrence of solar light pillars belonging to what Bravais has called "pillars of the first class" and also to what he calls "pillars of the second class." Light pillars are not notably rarer than the other phenomena of the family of halos and parhelia or "mock suns." All these appearances owe their presence to the reflection or refraction of the light rays by very fine floating ice crystals of one form or another. The light pillar results from reflections from flat, horizontal ice surfaces slowly falling through the air and pendulating as they descend. In many cases, as in the one reported by Mr. Reusser, the light pillars appear alone, unaccompanied by other halo phenomena. This leads one to conclude that the crystal forms able to produce the curved halo phenomena are here absent.

At present one is scarcely justified in saying more than the above regarding the causes of these light pillars. The following explanation of the phenomenon, extracted from the most modern general work on meteorological optics, will serve to show the general line of reasoning of most writers on the subject; but one of the fundamental assumptions therein demands modifications pointed out by Prof. Charles Hastings on page 619 below. It remains for our students of the forms of cloud-building ice crystals to discover, photograph, and determine the frequency of occurrence of crystal forms competent to produce these light pillars. Perhaps they have already been photographed among the many forms recorded by Mr. Bentley (Monthly Weather Review, Annual Summary, 1902, 30: 607, Pl. 1-22) and by others—[C. A. Jr.]

LIGHT PILLARS.

[Extract from "Meteorologische Optik" by PERTNER & EXNER.]

The phenomenon of light pillars is briefly referred to in the MONTHLY WEATHER REVIEW for July, 1914, page 443 and figure 1 on page 437. They may be described and explained as follows:¹

Light pillars may be grouped into two well-defined classes: (1) Those that rest upon the horizon; (2) those

¹ Pernter, J. M. & Exner, Felix M., Meteorologische Optik. Wien, etc. 1902-10. pp. 397-399.

that are visible accompaniments of luminaries standing above the horizon. In both classes the light pillar lies in the luminary's vertical; those of the first class are only above the luminary; those of the second class may be either above and below it, or only above it. Bravais has called the first group "light pillars of the first order" and those of the second group "light pillars of the second order." Both classes are to be explained as due to reflections from the basal planes terminating columnar ice prisms unmodified by pyramidal faces, as they float in the air.

Light pillars of the first order are essentially due to the simple reflection of the sun's rays from the lower bases of hexagonal prismatic ice needles, when the sun is below, just in, or very close to the horizon. Naturally such prisms are directed vertically when falling through the air [see, however, the criticisms by Charles S. Hastings on p. 619], but they must also be oscillating slightly in order to produce the appearance of a light pillar. If the falling prisms are not oscillating then such prisms can produce only a reflected image of the sun at rest and such an image would appear to be just as far above the horizon as the luminary might be below the same. As soon as the luminary reached the horizon the reflection would disappear. On the other hand, when the elongated vertically directed prisms oscillate, then the amplitude of the oscillations determines how high the sun may stand above the horizon before the resulting light pillar fails to appear. Suppose, to begin with, that the oscillation amounts to 10° and is always in the vertical of the luminary, then when the latter attained an altitude of 10° every reflection to an observer's eye would cease. If the luminary were in the horizon, however, then, since a reflection passes through twice the angle of the mirror, the oscillation would stretch out the image of the luminary to an altitude of 20° , i. e., the image would form a light pillar 20° in height.

Light pillars of greater heights have been observed, and the cause of those 30° and more in height is still a matter of discussion, even for cases where the sun is several degrees below the horizon (of course in the latter case the pillar has the red color of the low-lying sun). I consider it certain that an oscillation of as much as 20° frequently occurs, and that it is not impossible for even greater amplitudes to occur.² It is true one may still assume that even the triple reflection would also furnish a sufficient number of luminous rays to contribute to the formation of the upper structure of the pillar, although there must be a considerable difference in the intensity. Thus, suppose a ray reflected from a lower basal plane and on its path to the eye intercepted by an upper basal plane in a favorable position, and that it is reflected upward from this plane to a second lower basal plane also favorably located, then the reflection from this latter surface is the third reflection and can bring the ray to the observer's eye. The writer, however, would resort to the phenomenon of threefold reflections only in the extremest cases of light pillars exceeding 40° in vertical extent. The difference in intensity between simple and threefold reflections, and particularly between threefold and fivefold, etc., is too great to permit observers to overlook the strikingly different degrees of brilliancy that must result therefrom if the pendulation remains small. Specially favorable conditions may, indeed, produce a more gradual gradation in intensity; but I here maintain

that one is not compelled to follow Bravais who, for the sake of consistency, must hold to the theory that the prism is practically fixedly vertical because his theory of the upper tangent arc of the halo of 46° demands this condition. We may at once assume that the pendulation amounts to 20° or 25° , and if need be may even assume that this value is exceeded, for we find it quite in the nature of things that small floating crystals may be forced quite far from the vertical as they fall through the air. The actual blinding brilliancy of these light pillars argues for a single reflection as their origin.

When the pillar is seen continued beneath the sun as the latter stands somewhat above the horizon, then the pillar is indeed to be referred to a threefold reflection. The width of these pillars is, however, greater than the solar diameter and for the reason that the pendulation of the prisms is not only in the plane of the sun's vertical but in all directions. For this reason the image of the luminary appears to suffer great longitudinal distortion, just as does the reflection of a light on a wavy water surface, and also appears somewhat wider although of course insignificantly so as compared with the lengthening. The light pillars undergo the same slight widening as a result of the prism pendulations not being restricted to the plane of the luminary's vertical.

Light pillars of the second order appear only during higher altitudes of the luminary. They are due to a twofold reflection from the basal planes of the vertical ice prisms, and appear above or below the luminary according to the relative positions of the two reflecting surfaces. Of course the pillars may appear above and below the luminary simultaneously. The light rays fall first upon an upper basal plane, whence they are reflected upward to a lower basal plane which throws them down to the observer.

ON HALOS.

[Extract from "Light" by CHARLES S. HASTINGS.]

An incisive and important work on halos, and their phenomena and theory is contained in the latter part of the work entitled "Light" by Prof. Charles S. Hastings, of Yale University. As this work is almost unknown to our meteorological observers, we reprint, by permission of the author, the concluding pages, 221-224 of Prof. Hastings's text.—C. A.

As this completes the explanation of all known features of the complex phenomenon called the halo, it may be well to collect them in tabular form. We will first give those of which the origin has been known for a longer or shorter time, with the name of the physicist who first found the true explanation.

1. Halo of 22° radius. Mariotte.
2. Parhelia of 22° . Mariotte.
3. Oblique arcs of Löwitz. Galle.
4. Tangent arcs to the 22° halo, which become the circumscribing oval with high sun. Young and Venturi.
5. Halo of 46° radius. Cavendish. (Unless objections given on page 219 [of the above-mentioned volume] in regard to this feature are valid.)
6. Horizontal tangent arcs to the 46° halo. Galle; perfected by Bravais.

² Bravais endeavors to show that an oscillation of only 4° is sufficient to produce these greater heights if one also calls upon the phenomenon of multiple reflection. He is forced to some such recourse, since he is unwilling to depart very far from his assumption that vertically floating prismatic needles are always free from oscillations. (See his *Mémoire sur les halos*, etc. Paris, 1847, pp. 168-169.)

¹ Hastings, Charles S. *Light. A consideration of the more familiar phenomena of optics.* New York, Chas. Scribner's Sons, etc. 1901. xi, 224 p. illus. 8°. (Yale bicentennial publications.)

To these must be added the following, which have not hitherto been explained at all, or wrongly explained because grounded upon theories which are untenable:

7. Lateral tangent arcs to the 46° halo.
8. Parhelic circle.
9. Paranthelia.
10. Anthelion.
11. The arcs above and below the 22° halo.
12. The short oblique arcs through the anthelion.
13. Spiral arcs through the anthelion.
14. Vertical columns.

There is, however, a celebrated halo that contains a feature not mentioned in the list, which has given a great deal of trouble to writers on this subject from the time of Huyghens down. It is a rather remarkable halo observed by Hevelius in 1661, and described fully in Smith's *Opticks*, Volume I, pages 221, 222, although with the exception of this feature it seems to have been a well-developed halo depending upon the presence of the *A* group for its chief characteristics. The exceptional feature is a circle, of which only the lower portions are shown in the figure illustrating it, everywhere 90° from the sun, and therefore a great circle. Bravais, who styles this as the most authentic of all extraordinary halos, cites all the explanations offered, points out their fallacies, but quite frankly declares his inability to propose any more satisfactory theory. Since I am forced to follow Bravais exactly in this respect, it may be well to review the evidence of the existence of the 90° circle, beyond that contained in the original record. There is nothing in the records of the time since Bravais which bears upon this point, at least a search by me has led to no result; hence we are confined to the three examples which that author finds.

The first [example] is found in the description of the halo observed at Melville Island, given by Parry and Sabine. The passage in the last paragraph of the quotation ["Light"], page 143, describing the faint light about a quadrant from the sun, is taken as an observation of the circle in question; but a most casual reading demonstrates that such an interpretation is an entire misapprehension.

The second instance is found in a very uncritical description of a halo seen at Derby in England, in 1802, and published in the *Philosophical Magazine*, Volume XII, page 373. In this case neither the name of the observer nor the place of the sun in the heavens is given. The passage in which Bravais finds evidence of the 90° circle reads as follows: " * * * the fourth (circle) circumscribed all the others, and was touched upon the western side by part of another of the same diameter." It is quite clear that this circle did not have a radius of 90° , not only because no ordinary observer would dream of calling a great circle of which the sun occupies the position of one pole, a circumscribing circle, but also because in that case another circle tangent to it and of the same diameter would be identical with it. Unquestionably, this fourth circle was the 46° halo, and the circle touching it was the upper tangent arc.

The final case appears to be much more conclusive. It is that of a lunar halo observed by Erman² in Siberia in 1828.

Here, with the most minute particularity, that traveler gives the results of his observations, together with the fact that at $10^h 30^m$ p. m., Tobolsk mean time, the measured distance of the moon from the vertex of an auroral arch was 83.2° ; moreover, that at the same instant the lunar halo intersected the auroral arch a few degrees to the

west of its vertex. This seems very convincing as to the existence of a halo with a radius of 85° to 90° ; but reference to the details of the original account shows certain peculiarities which can not fail to awaken strong doubts concerning this conclusion. In the first place, Erman describes the halo without any intimation that it is an unusual one. Then he mentions the fact that it coincided with a part of one of a system of concentric arcs which are supposed to be auroral on account of their fixity of position with respect to the earth. Finally, he gives the measured distance of the moon from the apex of the lowermost arch at $6^h 30^m$ in the evening, which he found to be 86° . At this time the moon was close to the horizon; consequently, if the radius of the halo was 90° it would have intersected all the auroral arches nearly orthogonally, and a partial coincidence at any point would have been quite out of the question. But this is not the only inconsistency. An investigation as to the position of the moon at the place given and at the epoch of November 24, 1828, $10^h 30^m$ p. m., shows that its true distance from the point indicated as marking the place of the vertex of the auroral arch was 107° ; hence Erman's statement is erroneous.

But it is quite easy to supply to the printed account an emendation which eliminates all the difficulties and contradictions. We find that, on the evening in question, the distinguished traveler was at Sawodinsk, a place 2° north of Tobolsk, engaged in making a complete and protracted set of observations on the magnetic elements of the place. During the intervals of these observations—important as a part of a very elaborate system—he entered in his notebook the contemporary phenomena of auroral arches and the halo. At the later hour named he made the angular measure, probably with a sextant.

So much is certain. Now let us suppose that he chose the easy task of measuring the distance between the summit of the auroral arch and the nearest point of the halo instead of the less simple task of measuring the interval separating this summit from the relatively brilliant moon, in which case he would have been obliged to experiment with the dark glasses which are not well adapted for this kind of work. Under this supposition and the assumption that the halo was the ordinary one of 22° , we find that the distance separating the apex of the arch and the moon was 105.2° , which accords well enough with the astronomical fact. The only other modification necessary is to assume that the circle which intersected the auroral arch a few degrees to the west of its vertex was the vertical circle through the moon instead of the circle which accompanied the moon. With these highly plausible assumptions the records of a trained observer are made perfectly clear and probable, while without them they are entirely self-contradictory; yet with these modifications the last bit of confirmatory evidence for the 90° -halo of Hevelius falls to the ground. It does not seem unphilosophical to conclude that an inexplicable phenomenon recorded only once in a quarter of a millennium does not really exist.

Addendum of December 15, 1914, by Prof. C. S. Hastings.

In recent letters from Prof. Hastings he says:

"I found Bravais's theory quite untenable, which perhaps had occurred to many others. Bravais's extended collection of records was of great importance to every investigator in this field, but his theories to explain the phenomena were far from happy. The results of my own study in this field are embodied in a book entitled

²Erman, *Reise um die Erde*, vol. i, p. 544.

"Light" (Chas. Scribner's Sons, New York, 1901), where pages 139 to 153, inclusive, are given to a popular discussion of halos, and in Appendix C, [is given] a more rigid treatment with criticism of Bravais's views together with a substituted theory, which, in my mind, is acceptable. In this I succeeded in explaining all of the authenticated phenomena of halos, 14 in all, with the exception of the famous 90°-circle of Hevelius which would be the 15th. At that time I was almost disposed to question the reality of this feature; now, my attitude is somewhat changed, and I am inclined to a belief that it admits of theoretical explanation. This explanation I have not published because certain of its assumptions are not sufficiently based upon observation. * * *

"The first and most voluminous writer upon the subject, and perhaps the most philosophical, was Bravais. Bravais's fundamental errors were the following: (1) an error in mechanics contained in the assumption that elongated crystals would fall through the air with their axes vertical and plate-form crystals with their axes horizontal; (2) that ordinary reflections from the faces of such crystals could produce anywhere the notable increase in sky luminosity which characterizes the features of halos; (3) that he was justified in assuming the presence of any desired form of ice crystals convenient for his purposes provided that they did not contradict the laws of crystallography, overlooking, moreover, the fact that in order to attain his explanation he must assume the great predominance of that particular type in just the desired direction.

"Writers who have followed Bravais have, to the best of my knowledge, corrected only the first of these fundamental errors, namely, the mechanical ones. The optical and the crystallographical have not been touched, see figures 12, 13, 14, of page 434 of the MONTHLY WEATHER REVIEW for July, 1914.

"Let us consider briefly the significance of the three criticisms above, or rather, since everyone agrees as regards the first, let us turn our attention to the others. When we regard an ordinary feature of the halos, the 22°-ring for example, the origin of which is explained to the satisfaction of everyone, it will be observed that very nearly all of the light which enters a face of a suitably oriented crystal emerges in the direction of the observer other crystals present merely diluting the phenomenon. Now imagine the amount of light sent from such oriented prisms reduced to one-twentieth or less, can anyone suppose that under such circumstances any very marked or even notable increase of luminosity could be found in this region? But this is just the ratio of the decrease of luminosity when one depends, as do all of these writers, upon ordinary reflections from the crystals.

"As to the third criticism, it hardly needs more than a statement to render it valid. That Bravais should have premised a large number of unknown crystal forms merely because he thought they would meet his theoretical requirements is not so surprising; but that anyone else should invent a host of new forms which have an even less probable actuality is certainly very surprising. The tremendous outstanding objection to this method, which appears above, has never been touched upon as far as I know—I mean, that even granting the existence and efficiency of those highly complicated crystals one must put them in enormous numerical majority in just the required direction in order to be effective.

"The principles at the base of my theory are also three, and of the simplest kind: (1) Only such forms of ice crystals as have been observed and are of very simple type can be presupposed. This is an almost self-evident

condition since the phenomena necessarily infer an exceptional homogeneity of forms, for otherwise since prescribed forms only are effective, the presence of all others would only add to the whiteness and opacity of the sky; (2) the orientation of the crystals in falling must obey the law of mechanics; (3) all of those features of halos which are attributable to reflections must find their explanation in every case in total reflections.

With these narrow restrictions, made by no other writer, I had [in 1900] succeeded in explaining all well authenticated phenomena of this class with the postulate of only 2 forms of perfectly well-known crystals."

SYSTEMATIC EXPLORATIONS OF THE UPPER AIR WITH ESTIMATES OF COST.¹

By MARK W. HARRINGTON, Chief, U. S. Weather Bureau.

[Read before the International Conference on Aerial Navigation, Chicago, Ill., August, 1893.]

[This paper is of such historical value that we reprint it in full from the original for the information of students of meteorology. The paper was briefly referred to in the Monthly Weather Review, June, 1897, 25: 313, and January, 1914, 42: 39.

Many will be interested to learn that Prof. M. W. Harrington is still quietly living near Philadelphia, Pa.—C. A.]

The exploration of the upper air is the immediate requirement for the satisfactory advance of meteorology. There is abundant reason to think that many of the changes which go under the name of weather have their origin at some distance above the earth; and of what occurs in the cloud layer or layers, our knowledge is insignificant or theoretical. The only systematic attempt to investigate the higher atmosphere has been by means of mountain stations; but this, though it has led to a series of interesting results, does not meet the requirements of the meteorologist. The station on the mountain top is after all only a station on the earth's surface; and though many of the equidynamical surfaces show change with the elevation of the land (the isobaric, for instance), others (as the isothermic and those for wind and humidity) show marked adaptation to the contour of the surface. Many aeronauts have noted this adaptation as especially true of the cloud layers, the lower one often reproducing with some exactness the general variation of the surface below. We can hardly expect, therefore, that the mountain stations, useful as they are, will give us the aid needed in ascertaining what goes on at considerable elevations in the free air.

There are several ways of exploring the upper air by investigating the ray of light which has passed through it. The spectroscope promises much in this direction. The twinkling of the stars might be expected to give us a great deal of information when properly interpreted; Señor Ventosa has shown that even the fluctuations on the margins of the larger celestial bodies, when viewed in the telescope, have apparent relations with the upper winds. This information must, however, be vague, because the total result received by us is the integration of the individual effects at each point of the path, and it is not practicable to separate the sum into its parts. Besides, even if this could be done, the information to be obtained would be very incomplete, as it would relate only to a part of the series of meteorological elements. It may be mentioned as of interest in this connection that the scintillation of stars has been especially and systemati-

¹ Reprinted from pp. 349-354 of Proceedings, International conference on aerial navigation, Chicago, Aug. 1, 2, 3, and 4, 1893. Amer. eng. and rail'rd jour. New York, 1894, iv, 429 p. 8°.

cally studied; and M. Dufour, one of the leading students of the subject, has recently announced (*Archives des Sciences Phys. et Nat.*, June, 1893) that the only meteorological result he has been able to reach is the rule that lessened twinkling indicates bad weather.

There remain as means of systematic exploration of the free air, elevated towers, kites, pilot balloons (without aeronauts), and balloons carrying aeronauts. The elevated towers are well illustrated by the Eiffel Tower in Paris. By such a tower a systematic study may be made of a layer of air 1,000 feet thick, with almost infinitesimal perturbations by the tower itself. The excellent series of observations made by the French National Service on the Eiffel Tower have proved of very great interest, yet they do not reach to the height needed for the study of the upper air. It tells us nothing of what happens in the cloud layer, probably the most important of the strata of the atmosphere. Moreover, such towers are very expensive to build and to maintain. I have heard the cost of the Eiffel Tower estimated at \$1,000,000, and its maintenance must cost a considerable sum, which could only be met by using the tower as a permanent show place; the latter requirement necessitates its being placed in or near some great city.

The method by kites has been studied especially by Mr. William A. Eddy, of Bergen Point, N. J., and the data which I give I owe entirely to his kindness. He uses tailless kites, places them in tandem, and recommends that they be flown in groups of three. By such means he has already attained heights of 4,000 to 5,000 feet, and confidently expects to attain 14,000 feet without serious difficulty. On my request that he estimate the cost of carrying meteorological instruments to this height, he gave me the following estimate, on the basis that the line would average an angle of 45° with the horizon, and would have to be about 23,000 feet in length.

Cost to carry instruments to 15,000 feet height by means of kites.

			Breaking strain.	Cost.
			Pounds	
8 highest kites.....	12,000 ft.	Cable-laid twine.....	250	\$6.00
8 next kites.....	3,000 ft.	1/4-inch rope.....	540	6.00
8 next kites.....	3,000 ft.	1/4-inch rope.....	1,280	12.20
9 next kites.....	5,000 ft.	1/4-inch rope.....	2,250	30.50
Sum.....	23,000 ft.			54.70
<hr/>				
KITES.....	8 kites 5 feet across			\$16.00
	8 kites 6 feet across			20.00
	8 kites 8 feet across			24.00
	9 kites 9 feet across			31.00
Sum.....	33 kites.....			91.00
<hr/>				
Windlass for winding kites				\$20.00
4 laborers, at \$1.50 per diem				6.00
				26.00
Total.....				171.70

Mr. Eddy adds "that in lighter winds perhaps 50 kites would be required, the above estimate applying for winds of about 10 miles per hour. All the kites are tailless, and fly at an angle of about 80° from the horizontal for the first 300 feet of line out. In case the pull becomes too great for the breaking strain, the low and larger tandem kites can be hauled in. The breaking strain of the cordage must be known and the pull at the earth's surface constantly measured to prevent the entire line from breaking away. This is a rough estimate, but is founded upon careful experiments during two years. The top

kites and twines should be laid out the night or day before and the lines should be extended along the ground for several thousand feet. Soon after daybreak the top kites should be started up, the top one lifting the next, and so on. The kites will right themselves, regardless of position in which they are when lifted by the higher kites. Instruments should be suspended between 2 groups of 3 kites each, thus (see figure omitted).

"Three tailless kites will fly when any one of the three will not, in very mild surface winds. For safety it would be well to have the kites in groups of threes."

Mr. Eddy is not ready to give a limit to which kites can be flown, but is not without hope that they can be made to reach the cirrus clouds. In winds of high velocity the kites must be perforated to relieve them from too strong air pressure. The tailless kites easily right themselves when reversed, and a tandem series of kites tends to prevent the jerking which might put the instruments out of order.

It seems, therefore, that for about \$200 we may hope by means of kites to take instruments for registry to the height of about 14,000 feet. If we assume a loss and wear of 5 per cent per day in the kites and other apparatus, we would have a current expense of \$10 per day. Add to this the \$6 for labor, and such service would cost about \$16 per day. This would make for current expenses for a year \$5,840; add cost of instruments, \$2,500; outfit and incidentals, \$1,660; total, \$10,000.

A probable cost, then, of \$10,000 for a year's systematic work of this sort, not including the salary of the official in charge.

PILOT BALLOONS.

The best possible anemometer is a balloon which is immersed in the air and moves freely with it. For half a century or more occasional studies of the lower air currents have been made by means of small pilot balloons. The balloon is allowed to rise freely, and a card is attached to be returned by the finder with name, date, and place. The most elaborate series of observations of this sort known to me are those of M. Louis Bonvallet at Amiens, who, from May, 1888, to the end of 1890, sent up 97 paper balloons varying in volume from 50 to 1,800 liters. The general results are given by M. Gaston Tissandier in *La Nature* (Paris), 1891-92, pages 259-260. The amount of instruction from them is small and disappointing.

Such balloons can be used only for the study of air currents, but by a proper selection of places and dates and the assistance temporarily of theodolites and persons capable of using them these balloons could be made very useful. They would enable us to study the arrangement of air currents about definite meteorological phenomena, such as centers of high or low pressure. To effect this the observer should have a supply of small balloons on hand and the means of readily inflating them. He should also have on ready call two theodolites and persons capable of using them—a requirement easily filled at any college or university with a department of civil engineering. The weather map should be carefully studied from day to day, and when a "high" or "low" is about to pass over the station the force of observers should be called out and the balloons inflated and released to as great a number as could be observed at frequent intervals (once in 5 minutes, say), and with approximate precision. Computation would then easily show the horizontal motion at determinate elevations below the cloud layer, and plotting would show the relation of these to the center of pressure. Aside from the salary of

the principal observer, the cost of such observations would be small for each opportunity to observe, and for any given station the number of opportunities during the year would be few. The expense at any station for a year would probably not surpass \$150, so that for \$3,000 such observations could be scattered at 20 colleges over the States, with probable results far in excess in value over the cost.

A more instructive but more expensive method is that of pilot balloons carrying automatic registering instruments. This method of sounding the upper air was proposed by Le Verrier in 1784, and has within the last few years been repeatedly tried in France. In the last four months of 1892 M. Hermite sent up 13 such balloons, all of which reached an altitude of over 9 kilometers, or 6½ miles; and one sent up on March 21, 1893, must have reached an elevation of over 16 kilometers, or 10 miles. These balloons carry means for the automatic record of pressure and temperature, but the last-mentioned found so cold temperatures that for a considerable time the specially prepared ink could not perform its functions. They also carried a device for releasing and dropping cards, to enable the following of the course of the balloon; but this has not been successful, as the fuse which releases the cords is soon extinguished. In the ascent of March 21, out of 600 cards taken up only 400 were released, and of these only 5 or 6 were recovered. It is found, however, that the recovery of the balloon is much easier than had been expected, as a printed direction on the balloon itself leads to its recovery as soon as it falls into the hands of any intelligent person.

The difficulties in the way of these remarkably interesting explorations prove to be less than could have been expected; but there are many questions about them still unsettled. Under these circumstances it is not easy to make an estimate of the cost of systematic work in this direction. I have, however, asked Prof. H. A. Hazen to make the estimates for me. He has estimated approximately that a balloon to ascend to a height of 4 miles with a load of instruments of 20 pounds would cost \$150 if made of silk and \$200 if made of goldbeater's skin. For a balloon to ascend to the height of 10 miles he puts the corresponding prices at \$600 and \$800. The instrumental outfit would have to be prepared expressly and would be expensive. Probably the sum of \$5,000 would permit of one such pilot balloon per week during the year to the height of 4 miles, and perhaps one per month to the greater height. The station selected for such observation should be near the middle of the continental area—say somewhere from Kansas to Manitoba.

BALLOONS WITH AERONAUTS.

The preceding methods, while they would give highly interesting and instructive results, are somewhat imperfect as means of obtaining all the information needed by meteorologists. Much better for this purpose would be systematic work by a meteorologist who should make the ascension himself. Evidence points to the conclusion that the cloud layer, and perhaps the upper cloud surface, is a region of especial activity in meteorological phenomena, but the facts on which such a conclusion could be verified are of such character that they would probably escape any automatic registry. Their record requires the presence of a trained meteorologist. These observations should be systematic, as the sporadic ones are of relatively little value. A meteorologist should ascend twice a day to a considerable height, and should keep this up through all kinds of weather and through the season.

The elevation need not be great; probably the first 20,000 feet include the layer of air in which the meteorological phenomena which we call weather are active. At least the stratum of this thickness is far more important to us than all the rest of the depth of the atmosphere.

The cost of such a campaign would be considerable, but would vary with the material used, the care in using it, the position of the station, etc. I think a year's campaign of this sort could be gone through for an expense of \$20,000.

In conclusion, it appears that a year's campaign could be made in the free air as follows:

To 3,000 feet (perhaps), with small balloons.....	\$3,000
To 14,000 feet, with kites.....	10,000
To 20,000 feet, 52 pilot balloons.....	3,000
To 50,000 feet, 12 pilot balloons.....	
To 20,000 feet, with aeronaut.....	20,000

The results to be obtained would be cheap at any of these prices, but the fourth method seems to me incomparably the best as well as the most certain. A year's campaign of this sort would add very greatly—more than in any other possible way in the same time—to the knowledge of meteorology and hence to the forecasting of the weather. There is no other way, I believe, in which this sum of money could be expended to the greater advantage of meteorology.

(NOTE.—Upon the reading of the above paper it was, upon motion of Mr. D. Torrey, unanimously resolved [by the Conference]:

"That it is the sense of this meeting that the experiments proposed by Mr. Harrington are likely to prove of public value in forecasting the weather, and that Congress should, in our judgment, make the necessary appropriation to have the experiments made as recommended by Mr. Harrington.")

EXTRACTS FROM THE ANNUAL REPORT OF THE SMITHSONIAN ASTROPHYSICAL OBSERVATORY.¹

C. G. ABBOT, Director.

[Dated: Washington, D. C., June 30, 1914.]

Observations [at Washington].—Mr. Fowle has continued the difficult research on the transmission through moist air of radiations of great wave length, such, for instance, as those which bodies at the temperature of the earth emit most freely. He uses a very powerful lamp made up of a large number of Nernst electric glowers, and examines by the aid of the spectrometer the energy spectrum of the rays emitted by this lamp, first directly, and then, after the rays have traversed twice or four times a tube 200 feet long, containing air of measured humidity. During the past year Mr. Fowle has been dealing principally with rays of the very longest wave lengths of the terrestrial energy spectrum which moist air transmits. He has reached a wave length of about 18 microns, which is about 25 times the longest wave length visible to the eye, and about three and one-half times the wave length of the solar rays investigated by this observatory in the years 1890 and 1900.

A great number of difficulties are met with. In the first place, great sensitiveness of the bolometer is required, owing to the feebleness of these rays. Attempts to use a vacuum bolometer have consumed much time, but not yet with entire success. Full success in this

¹ Extracted from Appendix 5 of Smithsonian Institution. Report of the Secretary for the year ending June 30, 1914. Washington, 1914. iii, 117 p. 4 pl. 1 fig. 8° (Publication 2317.)

seems now probable. In the second place there is great difficulty in determining the amount of radiation lost in the optical train required to reflect the beam to and fro through the long tube. A principal difficulty in this matter arises from the fact that the lamp and its surroundings are unequally hot at different parts, for this has led to different degrees of loss at different wave lengths. This last source of error is so obscure that it escaped our attention for a long time and has required the observations to be repeated after results worthy of publication had, as it was thought, been reached. These and a host of other difficulties have delayed the research, but great hope is now felt that satisfactory results will be ready for publication in another year.

Computations.—Mr. Fowle has continued the study of the effect of terrestrial water vapor on the Mount Wilson solar observations and has published several valuable papers on it. An interesting result is, that after determining and correcting for the effect of atmospheric water vapor on the transmission of solar rays the coefficient of atmospheric transparency determined at Mount Wilson when combined with the barometric pressure after the manner indicated by Lord Rayleigh's theory of gaseous scattering of light, yield the value 2.70 billion billion as the number of molecules at standard pressure and temperature in a cubic centimeter of gas. Prof. Millikan, by a wholly independent kind of reasoning, has derived from electrical experiments the value 2.705 billion billion. The close agreement found is a strong confirmation of the accuracy of our determinations of atmospheric transparency, and accordingly tends to increase confidence in our determination of the solar constant of radiation.

Sky radiation instruments.—The director and Mr. Aldrich have devoted much time to the design and testing of apparatus for measuring the scattered radiation of the sky by day. What is desired is an instrument exposing horizontally an absorber of radiation in such a manner that the rays of the entire visible hemisphere of the sky would be received upon it, all rays not of solar origin would be excluded by a suitable screen, and the total energy of the scattered sky radiation originally emitted by the sun would be measured accurately. This is a more difficult problem than the measurement of the direct solar radiation, and it is unlikely that quite as high precision can be attained with the sky radiation instrument as with the pyrheliometers used for measuring direct solar radiation. From experiments with several instruments of the kind which have been constructed in the observatory shop by Mr. Kramer and tested by Messrs. Abbot and Aldrich it now seems probable that the sources of error can be so far eliminated that sky radiation measurements accurate to about 2 per cent will be made. An instrument embodying what are thought to be the final improvements of design is now under construction, and it is hoped it will be used a great deal in the coming year.

Balloon pyrheliometers.—Still more time has been devoted by Messrs. Abbot, Aldrich, and Kramer to the reconstruction and testing of balloon pyrheliometers. Mention was made in last year's report of the proposed measurements of solar radiation by apparatus attached to sounding balloons and raised to great elevations. As stated below, the first trials in August, 1913, while unexpectedly successful in many ways, did not enable us to obtain measurements above the elevation of about 14,000 meters, or 45,000 feet. At this elevation the mercury froze in the thermometers. Also, the clockwork proved not sufficiently accurate for best results. Still

the results obtained were so promising that it was thought well to repeat the experiments.

Accordingly, the 5 balloon pyrheliometers were reconstructed. Excellent French clocks were substituted for those used in 1913, and many improvements of the instruments were introduced. Two devices were employed to prevent the freezing of the mercury in the thermometer. In some instruments water jackets, having numerous interior copper bars to act as heat conductors, were arranged. In these it was hoped to make available the latent heat of freezing of the water and thus to prevent the surroundings of the pyrheliometric apparatus from descending far below the freezing point of water. In other instruments electrical temperature regulators were provided. Many experiments were tried to obtain a constant, powerful, and very light electric battery for this purpose. At length a modification of the Roberts cell was designed in which individual cells weighing 20 grams (three-fourths ounce) would furnish a constant potential of 1.3 volts and yield a nearly constant current of about 0.5 ampere for nearly two hours. The internal resistance of the cells was only about 0.3 ohm. Barometric elements were made to record on the same drum that recorded radiation. One instrument was constructed to be sent up at night, so as to show if any unexpected phenomena occurred when the instruments were being raised apart from those due to the sun. Many tests of the instruments were made at different temperatures and pressures, and while immersed in descending air currents comparable to those anticipated to attend the flights.

Silver-disk pyrheliometers.—As in former years, a number of silver-disk pyrheliometers were standardized at the Observatory and sent out by the institution to several foreign Government observatories.

Mount Wilson expedition of 1913.—Mr. Aldrich went to Mount Wilson early in July, 1913, and carried on there solar constant measurements until September, when he was joined and then relieved by Mr. Abbot, who continued the observations until November. An expedition at the charge of the private funds of the Smithsonian, and under the direction of Mr. A. K. Ångström, was in California during July and August for the purpose of measuring nocturnal radiation at different altitudes, ranging from below sea level to the summit of Mount Whitney, 4,420 meters (14,502 feet). Mr. Aldrich cooperated as far as possible with this expedition.

Balloon pyrheliometer.—At the same time a cooperating expedition from the United States Weather Bureau² made ascents of captive and free balloons in order to determine the temperature, pressure, and humidity at great elevations, for use in reducing Mr. Ångström's observations. Advantage was taken of the opportunity to send up special pyrheliometers for measuring solar radiation at great altitudes. These experiments, which were made jointly by Mr. Aldrich, and Mr. Sherry of the Weather Bureau, were referred to by anticipation in last year's report. Five balloon pyrheliometers were sent up from Santa Catalina Island. All were recovered with readable records. One instrument unfortunately lay in a field about six weeks before recovery, and parts of its record referring to the higher elevations were obliterated, but it yielded the best results of any up to about 8,000 meters. Two of the instruments unfor-

² See MONTHLY WEATHER REVIEW, Washington, 1914, 42: 410-426.

unately were shaded by cirrus clouds until after the mercury froze in their thermometers. The highest elevation at which a radiation record was obtained was about 14,000 meters, or nearly 45,000 feet. As stated in last year's report, no results indicating that values of radiation exceeding our solar constant value (1.93 calories) are obtainable by pyrheliometric measurements at any elevation, however high, appear from these balloon pyrheliometer experiments. In view of the proposed repetition of the experiments with improved apparatus no further statement of these preliminary results is necessary here.

The tower-telescope work.—As stated in former reports, investigations were carried on at Washington during the years 1904–1907 to determine the distribution of the sun's radiation along the diameter of the solar disk. It was shown by this work, in accord with results of earlier observers, that the edge of the solar disk is much less bright than the center, and that this contrast of brightness is very great for violet and ultraviolet rays, but diminishes steadily with increasing wave lengths and becomes very slight for red and especially for infra-red rays. * * *

The measurements were continued at Washington on all suitable days in the hope that some fluctuation of this contrast of brightness between the edge and center of the solar disk would be disclosed. It seemed probable that there might be such fluctuations associated with the irregular variability of the total solar radiation. It proved, however, that such fluctuations, if existing, were of so small an order of magnitude that it was not certain whether they were really shown by the observations at Washington, hampered as these were by variable transparency of the air.

When the observing station was erected on Mount Wilson in 1908, provision was made for a tower telescope designed to continue this research. When in 1911 and 1912 the Algerian expeditions confirmed the sun's variability, added interest was felt in the proposed experiments. Accordingly, the tower, 50 feet in height, was completed in 1912. Not sufficient funds were available to equip the tower telescope, but Director Hale, of the Mount Wilson Solar Observatory, kindly loaned considerable apparatus, and with this and some apparatus which remained from eclipse expeditions, and by using anything available, as, for instance, a trunk of a tree for a mirror support at the top of the tower, Messrs. Abbot and Aldrich succeeded in getting arranged on the tower a reflecting telescope of 12 inches aperture and 75 feet focus, all ready for observations by September 9, 1913. Then and thereafter solar constant measurements were supplemented by determinations of the distribution of radiation along the sun's diameter on each day of observation. These determinations are made in seven different wave lengths on each day, ranging from 0.38μ in the ultraviolet to 1.1μ in the infra-red. Fortunately, the definition of the tower telescope proves to be very good. There is slight change of focus during the several hours of observing, and the "seeing" seems not to deteriorate much up to 10 a. m., at which time the observations are generally concluded.

About 45 days of simultaneous observations of the "solar constant" and of the distribution of radiation over the sun's disk were secured in 1913. The results appear to indicate a variability in both phenomena and a distinct correlation of the two in point of time. It is indi-

cated that when in course of its short-period irregular variation the solar radiation increases, there occurs simultaneously a diminution of the contrast between the edge and center of the sun's disk. A change of brightness of about 1.5 per cent was found to occur at 95 per cent out on the solar radius accompanying a change of 6 per cent in the solar radiation. On comparing the mean of all results obtained in 1913 with the mean of all obtained in Washington in 1906–7, it appears that there was distinctly less contrast of brightness between the edge and center of the sun's disk in 1913 than in 1907. We have reason, however, to believe that there was distinctly a greater total solar radiation in 1907 than in 1913. This result, compared with the result stated above, indicates a difference of character between the long-period fluctuations of the sun and its short-period irregular fluctuations. The changes of contrast found, however, agree in this, that whether from day to day in 1913, or as between 1913 and 1907, the violet or shorter wave-lengths change in contrast more than the red or longer wave lengths. * * *

THE AMERICAN METEOR SOCIETY.

By Prof. CHARLES P. OLIVIER.

[Dated: Charlottesville, Va., December 25, 1914.]

The American Meteor Society was first organized in the latter part of 1911, and from that time to the present has endeavored to stimulate interest in this much neglected branch of astronomy.

As must necessarily be the case, most of its members are amateurs, but there are several professional astronomers also enrolled. At the present time it contains about 20 members, the larger part being also members of the Society for Practical Astronomy, whose "Meteor section" forms far the most active group of our workers.

The purpose of the organization is to stimulate interest in observing and recording meteors along carefully planned and uniform lines, to collect this data at a central office, and to have the results computed and published in scientific form.

Circulars are furnished describing our methods and blank forms for the records are sent free on application. Also prospective members are advised where to secure suitable maps and anything else they may desire. All persons interested in this subject are urged to join us and are assured that they will receive full credit for any work submitted. The results from 1911 to 1913, inclusive, have been carefully worked up and printed as volume 2, part 4, of the publications of the Leander McCormick Observatory of the University of Virginia. In all, 126 parabolic orbits of meteor streams and many other results of interest were obtained from the 2,800 meteors there discussed. We would be very glad to secure any unpublished meteor records of any year whatever and to undertake their discussion and reduction. All communications and inquiries are to be addressed to Charles P. Olivier, Leander McCormick Observatory, University of Virginia. As scientific work in Europe is at present so greatly hindered, it is especially hoped that American observers will do more than their share during 1915 in observations of meteors.

[See also the MONTHLY WEATHER REVIEW, January, 1913, 41: 162.]

THE DREXEL AEROLOGICAL STATION.

The Drexel farm buildings and an adjoining 40-acre tract of high, level land have been leased, November 1, 1914, for the purpose of installing the equipment necessary for more permanent aerological work than has heretofore been attempted in the Middle West. The Drexel farm is about 20 miles west of Fort Omaha, Nebr. Mail reaches the aerological station established there through the post office at Washington, Nebr.

The installation being made on the Drexel farm is for the purpose of kite flying and the related surface observations such as have previously been made at Mount Weather. We have the use of the large electrolytic hydrogen plant at Fort Omaha, near Omaha, Nebr., and it is planned to supplement the lower kite observations

with occasional series of free balloon ascensions from the fort.

As soon as the equipment can be got ready, two or three other aerological stations in the Middle West will be started. These stations will be supplied with hydrogen for free balloon work from the central Drexel-Fort Omaha station and will cooperate with the latter in obtaining data. The value of these data is not expected to be found so much in their current use, though many of the observations are individually useful, as in the light thrown by them on the whole subject of dynamic meteorology. Data are therefore obtained and grouped in such a way as to most illuminate the problems under consideration. Such use of the data governs so far as is practicable the place and time of observation.—[W. R. B.]

SECTION II.—GENERAL METEOROLOGY.

ON A METHOD FOR CLASSIFYING WINTERS.¹

By ALFRED ANGOT.

[Translated for the MONTHLY WEATHER REVIEW by Miss R. E. Edwards.]

The comparison of the temperatures of different winters presents some difficulties, particularly from the point of view of their influences on agricultural phenomena. The monthly means are certainly inadequate, for one month (e. g., February, 1913) may have a mean temperature that is close to the normal while the month had presented two quite different periods of which one was very warm and moist while the other was cold and dry. Equally unsatisfactory is an examination relying upon absolute extreme temperatures; the unusually warm winter of 1911-12 had but two very cold days, in February, when the temperature at Parc Saint-Maur fell to -10°C ., and this temperature if considered alone would lead us to class among the cold winters precisely the warmest one on record.

The influence of cold periods on the phenomena of vegetation depends both on their intensity and their duration. It is therefore necessary to seek for some method of presentation that will take into account both these elements. The simplest method seems to be to use the sum of the daily minimum temperatures that fall below 0° in each month. For example, in January, 1913, at Parc Saint-Maur there were but four "days of frost": -1.6°C . on the 1st, -0.5° on the 10th, 0.0° on the 26th, and -2.0° on the 27th; the sum of these four numbers is 4.1° , or 4° in round numbers—which are close enough, for although it is necessary to retain the tenths in the individual numbers in order to obtain an exact sum it seems illusory to retain them when discussing the sum itself.

The following table, Table 1, gives the values obtained in this manner at Parc Saint-Maur for the whole series of observations covering exactly 40 years. The values for October and November, 1872, when observations had not yet begun at Parc Saint-Maur, have been interpolated from observations taken at Versailles by taking into account the mean difference between the minima at the two stations. In the table leaders (.....) indicate there was no temperature below freezing during that month. 0 indicates that there were one or two days of very light freezing and that the sum of the negative temperatures does not amount to 0.5°C . The total for the year sometimes differs by unity from the number written in the last column headed "Totals," because in order to obtain the latter the decimals belonging to each month have been used.

The average annual total of minimum temperatures below 0°C . at Paris is 198.7°C ., or in round numbers 200°C . The annual total varies within very wide limits from year to year (e. g., from 52° for 1872-73 to 588° for 1879-80); therefore it provides a good criterion for classifying winters. The winters that furnished the largest and the smallest sums are, respectively:

	$^{\circ}\text{C}$.		$^{\circ}\text{C}$.
1879-80.....	588	1872-73.....	52
1890-91.....	447	1883-84.....	59
1894-95.....	412	1911-12.....	61
1887-88.....	323	1876-77.....	75

The 32 other winters of the period considered have all given numbers above 100° and below 300° . For the present winter (1912-13) up to March 12, 1913, the sum is 73.5; it therefore ranks fourth among mild winters and will pass to fifth place if, as is probable, not less than one or two days of light frost occur.

One could likewise take into account the daily maximum temperatures that fall below 0° in making up this table. This would emphasize still further the contrast between the mildest and the severest winters without essentially changing the general character of the winters.

It would certainly be interesting to calculate similar sums for some other stations where we possess long series of observations made under favorable conditions, and to compare the resulting data with the phenomena of vegetation.

In the accompanying table one should notice the two months December, 1879, and February, 1895; both present sums of negative temperatures in excess of the average annual sum. The influence of these two exceptional months raises the general averages for December and February. This is particularly striking in the case of December, which, at the end of a very great number of years, should present a much greater contrast with the average sum for January than is shown by the table.

TABLE 1.—Sums of minimum temperatures below 0°C . at Parc St. Maur, Paris.

Winter.	October.	November.	December.	January.	February.	March.	April.	May.	Year.
									$^{\circ}\text{C}$.
1872-73.....	1	1	2	12	27	5	4	.....	52
1873-74.....	1	9	46	21	48	23	1	2	151
1874-75.....	2	32	88	25	54	24	.....	.....	227
1875-76.....	1	17	67	112	71	11	6	.....	284
1876-77.....	1	19	2	18	7	28	.....	0	75
1877-78.....	14	.....	31	42	17	11	2	.....	118
1878-79.....	.....	6	72	86	15	6	7	.....	192
1879-80.....	2	40	391	122	31	3	.....	.....	588
1880-81.....	11	19	3	153	13	15	2	.....	215
1881-82.....	13	6	31	40	50	2	1	.....	143
1882-83.....	0	0	15	21	18	66	2	.....	122
1883-84.....	.....	4	16	4	11	16	8	.....	59
1884-85.....	2	38	24	119	2	20	.....	0	205
1885-86.....	.....	8	40	59	40	56	1	.....	204
1886-87.....	.....	2	35	73	66	62	5	.....	243
1887-88.....	13	16	54	87	100	43	9	.....	323
1888-89.....	14	.....	42	63	52	47	.....	.....	218
1889-90.....	.....	10	82	15	50	41	1	.....	200
1890-91.....	13	42	181	135	50	20	6	.....	447
1891-92.....	3	35	60	67	30	62	9	2	268
1892-93.....	1	.....	88	159	14	7	1	.....	270
1893-94.....	1	28	39	64	36	4	.....	.....	171
1894-95.....	.....	10	17	105	243	37	.....	.....	412
1895-96.....	8	3	10	34	51	2	0	.....	109
1896-97.....	.....	37	17	41	6	5	1	.....	106
1897-98.....	3	28	52	31	20	21	1	.....	155
1898-99.....	.....	4	38	15	48	52	0	.....	157
1899-1900.....	3	10	114	16	27	22	4	.....	195
1900-1901.....	2	3	1	56	101	24	1	.....	188
1901-02.....	1	45	30	23	62	4	0	1	165
1902-03.....	.....	34	75	47	21	18	3	.....	198
1903-04.....	.....	6	49	60	25	24	.....	.....	163
1904-05.....	1	27	25	82	17	2	4	.....	158
1905-06.....	15	17	25	28	31	17	2	.....	134
1906-07.....	.....	5	81	53	72	14	4	.....	230
1907-08.....	.....	7	19	124	22	27	5	.....	203
1908-09.....	5	27	62	73	68	31	3	2	270
1909-10.....	.....	27	32	37	24	7	4	.....	130
1910-11.....	.....	17	14	51	38	9	12	.....	141
1911-12.....	.....	5	1	21	32	.....	2	.....	61
Average.....	3.3	16.1	51.7	59.8	42.7	21.9	3.0	0.2	198.7

¹ Angot, A. Sur un mode de classification des hivers. Annuaire de la Soc. météorol. de France, Paris, Avril, 1913, 61: 109-112.

WASHINGTON AND PARIS WINTERS.

By CLEVELAND ABBE, Jr.

[Dated Weather Bureau, Washington, D. C., Nov. 10, 1914.]

The preceding interesting paper on classifying Paris winters has encouraged us to prepare and present here a similar table for the same period for Washington, D. C. Willis E. Hurd and Herbert Lyman have assisted in the computations.

The central office of the United States Weather Bureau, latitude 38° 54' north, longitude 77° 3' west, elevation (present) 73 feet, was established at Washington, D. C., by the Signal Service on November 1, 1870. The city is situated on the Potomac at the head of tide-water. On its establishment in 1870, the Weather Bureau station was located at 1719 G Street NW., where it remained until August, 1888. On August 15, 1888, the office was moved diagonally across the street to 1744 G Street NW. The station remained in this location only a few months when, on March 29, 1889, it was moved about 4,100 feet northwestward to its present location in the Ferguson Building, at the southwest corner of Twenty-fourth and M Streets NW.

The thermometers have always been exposed in a standard louvered shelter on the roof of the office building. At the Ferguson Building they are at an elevation of 59 feet above the ground and 9 feet above the roof. The exposures on G Street placed them 9.8 feet above the roof and 57.5 feet above the street.

In our Table 1, as in the corresponding table for Paris, leaders (.....) indicate that there were no days in the month when the minimum fell to 32°F. (0°C.); 0 indicates that the minimum fell to 32°F., but not lower, while the exponent figure of the 0 indicates the number of times this minimum temperature was recorded. In the last two columns of our Table 1 are given the annual totals, expressed in both Fahrenheit and centigrade intervals; the incomplete total for 1871-72 has not been used in computing the average annual total; therefore the latter does not closely agree with the sum of the monthly averages. The readings of the Weather Bureau Fahrenheit minimum thermometers are recorded to the nearest whole degree; hence there are no known decimals suppressed in our monthly columns and no decimals appear in our °F column of annual totals for the same reason. The decimals in the centigrade totals result from the conversion into sums of centigrade intervals ($\frac{5}{9}$ of the Fahrenheit sums).

The average annual total of minimum temperatures below 0°C. (32°F.) at Washington, D. C., is 462.0°C. and 203.3°C. larger (colder) than that of Angot for Paris. At Washington the annual winter sum has varied between 165.5 C. for the warm winter of 1889-90 and 674.4 C. for the cold winter of 1903-4, limits that are not as wide as are those for the Parisian winters of the same period, but seem to be wide enough. The seven winters with the largest and the smallest sums are, respectively:

	°C.		°C.
1903-04.....	674.4	1889-90.....	165.5
1880-81.....	637.2	1881-82.....	225.0
1904-05.....	619.4	1877-78.....	230.5
1872-73.....	566.7	1879-80.....	241.6
1892-93.....	553.9	1908-09.....	246.1
1884-85.....	551.1	1912-13.....	248.3
1874-75.....	540.0	1890-91.....	255.5

The sums for the remaining winters fall between 300.0° and 525.0°C.

One of the most striking points brought out by Table 1 and the above list of our coldest winters is the fact that the seven coldest winters, as measured by this method,

fail to include the winter of 1898-99, which brought the lowest temperature (-15°F. in February) that Washington experienced during the period covered by the table.

TABLE 1.—Sums of intervals below 32°F., attained by the daily minimum temperatures at Washington, D. C., from 1872 to 1914.

Year.	October.	November.	December.	January.	February.	March.	April.	Year.	°F.	°C.
1871-72....	(°)	(°)	(°)	264 ^a	193 ^b	207 ^a	2	.....	666	370.0
1872-73....	99	300	276	211	134	.....	1,020	.....	566.7	312.7
1873-74....	7	68	69	154	169	66	30	.....	563	312.7
1874-75....	0 ¹	45	108	319	373	101	26	.....	972	540.0
1875-76....	0 ¹	51	147	133	175	95	3	.....	604	335.5
1876-77....	2	13	389	332	89	103	0 ²	.....	928	515.5
1877-78....	.....	19	51	247	73	25	.....	.....	415	230.5
1878-79....	2	7	199	306	185	45	14	.....	758	421.1
1879-80....	4	75	83	63	147	58	5	.....	435	241.6
1880-81....	2	120	329	368	262	46	20	.....	1,147	637.2
1881-82....	34	60	203	75	26	7	.....	.....	405	225.0
1882-83....	53	187	281	87	148	6	.....	.....	762	423.3
1883-84....	57	129	312	83	74	0 ¹	.....	.....	655	363.9
1884-85....	0 ¹	24	162	253	352	198	3	.....	992	551.1
1885-86....	.....	3	101 ^a	331	254	71	.....	.....	760	422.2
1886-87....	.....	36	290	310	77	79	9	.....	801	445.0
1887-88....	1	35	126	302	164	173	0 ¹	.....	801	445.0
1888-89....	.....	28	131	80	213	105	0 ¹	.....	557	309.4
1889-90....	.....	18	49	57	47	119	8	.....	298	165.5
1890-91....	2	18	167	101	71	91	10	.....	460	255.5
1891-92....	2	61	99	254	135	117	1	.....	669	371.6
1892-93....	2	40	222	484	165	84	.....	.....	997	553.9
1893-94....	6	50	135	101	160	40	2	.....	494	274.4
1894-95....	.....	33	146	256	394	45	.....	.....	874	485.5
1895-96....	8	35	144	192	165	155	10	.....	709	393.9
1896-97....	1	15	209	304	103	25	3	.....	660	366.6
1897-98....	.....	26	106	123	202	25	15	.....	497	276.1
1898-99....	2	39	190	255	395	44	14	.....	939	521.6
1899-1900....	0 ¹	37	229	234	262	121	2	.....	885	491.6
1900-1901....	.....	22	162	185	290	69	.....	.....	728	404.4
1901-02....	0 ¹	81	234	243	277	45	0 ¹	.....	880	488.9
1902-03....	2	4	171	220	168	12	8	.....	585	325.0
1903-04....	.....	117	254	398	375	58	12	.....	1,214	674.4
1904-05....	8	41	282	340	369	69	6	.....	1,115	619.4
1905-06....	.....	63	136	78	242	99	8	.....	626	347.7
1906-07....	2	5	156	186	298	46	15	.....	708	393.3
1907-08....	2	28	111	213	249	29	3	.....	635	352.8
1908-09....	.....	39	123	162	71	41	7	.....	443	246.1
1909-10....	1	5	257	202	204	17	.....	.....	686	381.1
1910-11....	1	23	287	137	106	106	9	.....	669	371.6
1911-12....	.....	48	45	475	277	96	1	.....	942	523.3
1912-13....	.....	30	121	57	176	63	0 ¹	.....	447	248.3
1913-14....	.....	12	76	122	302	140	10	.....	662	367.8
Averages..	1.3	39.4	166.0	230.4	201.9	81.6	6.2	.....	723.7	402.0

NOTE.—a, b, c indicate 1, 2, and 3 days missing, respectively. (°) indicates no record. indicate no minimum as low as 32°F. 0¹, 0², indicate minimums fell to 32°F. on 1 and 2 days respectively but never fell below that temperature.

Table 2 shows at once by its column of differences that Paris has a warmer winter, usually a much warmer winter, than has Washington. On the average, the sum for a Parisian winter falls 203.3 units below the sum for a Washington winter, and this happens in spite of the fact that Paris lies 10° of latitude farther north. Since Paris lies about as far from the English Channel, (but farther from the Atlantic coast) as Washington does from our Atlantic coast, it is clear the warmer Parisian winter must be due to some other cause than mere proximity to the sea. The local topography is rather in favor of a warmer Washington, situated on a southward-facing slope, than a warmer Paris which is built on the floor of the basin of the Seine. The answer to the query raised by the contrasted winters is contained in the charts of the world showing the prevailing winter winds of the Northern Hemisphere (see Bartholomew's Atlas "Meteorology," Plate 14). The winter winds of France, notably western and northern France, are southwest winds that have swept over hundreds of miles of the waters of the subtropical North Atlantic before they reach the western shores of France. These surface winds have assumed almost the temperature that prevails in

the open oceans, of course a much higher temperature than the winter temperature of the lands and in this case not directly affected by drift from the Gulf of Mexico. Consequently the ocean-born air that drifts in over France during the winter has a temperature characteristic of the oceans of lower latitudes rather than of the continental land areas in the latitude of Paris. At Washington, on the other hand, the same charts show that its winter winds are drawn from the interior, not to say the great north-western interior of the continent of North America under its winter conditions. Such winds have assumed almost the temperature of the surface of the great continental interior and are drawn from even higher latitudes than that of Paris itself. There is thus a double reason why they are so continuously colder and drier than the air simultaneously passing over Paris. In brief, one may say that these tables comparing the severity of Washington and Paris winters furnish yet another demonstration of the already well known fact that the western margins of terrestrial continents enjoy milder winters than do the eastern margins. In this particular case, however, one may go further and show, as pointed out above, that western Europe owes its mild winters to its position on the eastern boundary of a great perennially open ocean; it is evident that even those places, such as Paris, far removed from the direct influence of the Gulf Stream have far milder winters than their latitudes otherwise enjoy.

TABLE 2.—Washington and Paris winters compared by Angot's method.

(Centigrade.)

Year.	Differences Paris— Washington.	Departures at—	
		Paris.	Washington.
1872-73.....	-514.7	-147	164.7
1873-74.....	-161.7	-48	-89.3
1874-75.....	-313.0	28	138.0
1875-76.....	-51.5	85	-66.5
1876-77.....	-440.5	-124	113.5
1877-78.....	-112.5	-81	-171.5
1878-79.....	-229.1	-7	19.1
1879-80.....	346.4	389	-160.4
1880-81.....	-422.2	16	235.2
1881-82.....	-82.0	-56	-197.0
1882-83.....	-301.3	-77	21.3
1883-84.....	-304.9	-140	-38.1
1884-85.....	-346.1	6	149.1
1885-86.....	-218.2	5	20.2
1886-87.....	-202.0	44	43.0
1887-88.....	-122.0	124	43.0
1888-89.....	-191.4	19	-92.6
1889-90.....	34.5	1	-236.5
1890-91.....	191.5	248	-146.5
1891-92.....	-103.6	69	-30.4
1892-93.....	-283.9	71	151.9
1893-94.....	-103.4	28	-127.6
1894-95.....	-73.5	213	83.5
1895-96.....	-284.9	-90	-8.1
1896-97.....	-260.6	-93	-35.4
1897-98.....	-121.1	-44	-125.9
1898-99.....	-364.6	-42	119.6
1899-1900.....	-296.6	-4	89.6
1900-1901.....	-216.4	-11	2.4
1901-02.....	-323.9	-34	86.9
1902-03.....	-127.0	-1	-77.0
1903-04.....	-511.4	-36	272.4
1904-05.....	-461.4	-41	217.4
1905-06.....	-213.7	-65	-54.3
1906-07.....	-163.3	31	-9.7
1907-08.....	-149.8	4	-49.2
1908-09.....	23.9	71	-155.4
1909-10.....	-251.1	-69	-20.9
1910-11.....	-230.6	-58	-30.4
1911-12.....	-462.3	-138	121.3
1912-13.....			-153.7
1913-14.....			-34.2
Average..	-203.3		

Plus differences indicate that Paris was colder than Washington. Plus departures indicate local cold winters.

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During the past 42 years, however, two winters (1879-80 and 1890-91) have been pronounced exceptions to the rule that Paris has milder winters than Washington, and two other winters (1889-90 and 1908-9) have presented slighter exceptions. The column of differences in Table 2 shows that the winter of 1879-80 was colder at Paris by the amount of 346.4 units. This change in sign, as well as the numerical difference, was due in part to the unusually warm winter then prevailing at Washington where its winter sum was 160.4 units above the Washington average, but in part it represents an actual long, cold winter at Paris. The column of Paris departures in Table 2, when taken with the monthly sums as given in the table on page 625, shows that December, 1879, at Paris, gave a sum of units 8 times larger than that for the average Paris December, and that it was the severest December Paris had experienced up to May, 1912. Washington was enjoying a December and January that were much warmer than the 42-year average. The second pronounced exception, the winter of 1890-91, was also an unusually warm one at Washington, where its departure amounted to 146.5 units below the average Washington winter sum as a result of a mild January followed by warm February and March (see p. 626). The same winter in Paris was actually the second coldest the city has experienced during the period under consideration, its departure of 248 units above the average being due to extreme and continued cold in December and January.

Of the two cases 1889-90 and 1908-9, the former is the more interesting since the balance in favor of Paris cold is here altogether due to exceptional conditions in North America; Paris enjoyed a strictly normal winter, as its departure of only 1 unit clearly shows. Washington experienced its most abnormally warm winter in this year. Its total "cold units," as shown by Table 1, page 626, amounted to but 165.5 C. units (298 F. units), thereby departing by 236.5 C. units from the average of 402 C. units. Table 1 shows that this warm winter was altogether in the months November to February, every one of which shows a sum far below the average monthly sums for those months, while March closed the winter with a sum much above the March average. The minimum temperatures for the winter months of 1889-90 were as follows:

TABLE 3.

1889-90	Novem- ber.	Decem- ber.	Janu- ary.	Febru- ary.	March.
Extreme minimum.....	°F. 27	°F. 22	°F. 19	°F. 24	°F. 13
Mean minimum.....	39.3	36.3	35.8	33.7	32.7
Average minimum.....	37	29	26	27	33
Departure of minimum.....	2	7	10	9	0

It appears from this little table of temperatures that the elements it presents do not fairly represent the winter 1889-90, as an unusual one at Washington, although it is apparent that the mean monthly minimum temperatures were somewhat above the average during the three months December to February. On the other hand Table 3 quite hides the fact that March, 1890, was much colder, all in all, than the usual March is. Its mean minimum of 32.7°F. was almost exactly the average March minimum, its extreme minimum of 13°F. was but little below the extreme minimum of January, 19°F.; whereas Table 1 shows that March, 1890, was much colder while January, 1890, was excessively warm.¹

¹ Those interested in the comparison of the two methods may find useful a compilation by Frank Gilliam in the MONTHLY WEATHER REVIEW October 1898 26: 456.

TABLE 4.—Summary of Table 2 comparing Paris and Washington winters.

Paris, cold	1880, 1887, 1892, 1894.....	4
Washington, cold	1906.....	1
Paris, cold	1875, 1879, 1888, 1890, 1891, 1908.....	6
Washington, warm	1874, 1878, 1880, 1884, 1885, 1899.....	6
Paris, normal	None.....	0
Washington, normal	1889, 1902, 1907.....	3
Paris, warm	1872, 1876, 1882, 1898, 1901, 1903, 1904, 1911.....	8
Washington, cold	1895, 1900.....	2
Paris, warm	1873, 1877, 1881, 1883, 1896, 1897, 1905, 1909, 1910.....	9
Washington, warm		

It is not the present purpose to further discuss the reasons underlying these constant differences between Paris and Washington or the occasional reversals in the relations. Undoubtedly their immediate causes are closely associated with the prevailing distribution of the great "centers of action," and the occasional disturbances arise from some dislocation of the latter. The chief aim has been to contribute the characteristic winter sums for Washington computed according to the method suggested by Dr. Angot; and to further examine the truth of his contention that these sums furnish a more useful and significant method for comparing winter conditions than do the usual means, extreme minima, and their departures.

It is hoped that in the future similar data for Washington may be presented for the period, 1838-1870, inclusive.

ON A METHOD FOR CLASSIFYING SUMMERS.¹

By ALFRED ANGOT.

[Translated for the MONTHLY WEATHER REVIEW by Miss R. E. Edwards.]

Several months ago the author proposed a method of classifying winters,² based on the comparison of the sums of the minimum temperatures below 0°C. These sums take into account both the intensity and the duration of the cold periods.

An analogous procedure may be applied to the summers by taking the sum of all the daily maximum temperatures above a certain limit. Take, for example, two different limits such as 25°C. and 30°C.; to form these sums one takes all the daily maxima, deducting from them the value which corresponds to the temperature chosen as the point of departure. In case 25°C. is selected as that point, a temperature of 25° or less will be counted as 0, a temperature of 26° as 1°, and so on. The two accompanying tables contain the sums of the maximum temperatures above 25° and 30°, respectively, at Parc Saint-Maur, Paris, for a period of 41 years. In Table 1 below it has seemed unnecessary to retain the fractions of a degree; the months in which the temperature has not once reached 25°C. are designated by leaders; the figure 0 indicates that there, on the other hand, the temperature has exceeded 25°C., but that the sum is less than 0.5°C. In Table 2 it has seemed necessary to give the fractions of a degree because of the smallness of the majority of the numbers that enter into the table.

Without going into a detailed study of these tables, we may indicate some of the general results they lead to.

Temperatures above 25°C.—The average annual total at Parc Saint-Maur is 117°C., distributed through the

seven months, April to October. The maximum monthly average sum is 43°C., and falls in the month of July. The annual sums are extremely variable, the three greatest and the three smallest are, respectively:

	*C.		*C.
1911.....	357	1910.....	22
1911.....	199	1882.....	31
1899.....	194	1879.....	37

During the 41 years here considered, then, the sums have varied between 22° and 357°; this gives a very extensive scale of comparison and permits a ready classification of the summers.

The maximum value, 357°, in 1911, is three times the average annual value and exceeds by nearly 160° the greatest maximum previously known, a fact that brings into prominence the altogether exceptional character of the summer of 1911. It is a curious fact that the two extremes of the series occurred in two consecutive years. One does not notice, at any rate not at first sight, that there is any periodicity in the hot summers and cold summers.

Not only are the annual sums very variable, but the distribution among the different months is also very irregular. The months that give the two largest sums in the average year are ordinarily July and August, but sometimes the largest sum characterizes June (as in 1877, 1878, 1885, 1888, 1889, 1897, and 1908), and in exceptional cases may even fall to September (as in 1891 and 1895). It would be interesting to investigate the relation of these sums to the phenomena of vegetation, and also the influence of early and late warm spells. These numbers seem to lend themselves better to this study than do the mean temperatures and the absolute extremes.

TABLE 1.—Sums of maximum temperatures exceeding 25°C. at Parc Saint-Maur, Paris.

Year.	April.	May.	June.	July.	August.	Sep-tember.	Octo-ber.	Year.
1873.....	0	.....	14	56	43	.....	1	114
1874.....	11	14	32	112	12	12	.....	193
1875.....	3	9	25	9	41	10	.....	97
1876.....	.....	2	19	75	92	1	.....	188
1877.....	.....	.....	65	30	36	1	.....	132
1878.....	.....	4	24	23	7	2	.....	60
1879.....	.....	.....	2	6	27	2	.....	37
1880.....	.....	17	9	43	31	21	.....	121
1881.....	.....	1	11	120	12	.....	.....	144
1882.....	.....	1	3	14	10	3	.....	31
1883.....	.....	18	16	22	38	.....	.....	94
1884.....	.....	17	16	75	76	.....	.....	193
1885.....	0	6	47	39	19	6	.....	117
1886.....	.....	8	4	45	39	25	1	124
1887.....	.....	.....	33	66	34	.....	.....	133
1888.....	.....	.....	28	3	22	7	.....	63
1889.....	.....	2	44	30	22	13	.....	111
1890.....	.....	9	11	21	17	2	.....	60
1891.....	.....	1	8	10	9	14	.....	42
1892.....	.....	38	19	32	60	7	.....	156
1893.....	14	4	39	45	69	6	.....	177
1894.....	0	7	12	41	16	6	.....	82
1895.....	.....	8	15	20	32	100	.....	186
1896.....	.....	4	16	55	2	0	.....	77
1897.....	.....	4	30	17	17	1	.....	69
1898.....	.....	1	3	16	86	42	.....	148
1899.....	.....	1	25	54	94	20	.....	194
1900.....	1	4	26	129	22	15	2	199
1901.....	.....	7	38	70	38	6	.....	150
1902.....	.....	2	15	43	11	5	.....	76
1903.....	.....	14	16	22	8	15	.....	75
1904.....	.....	10	15	117	46	.....	.....	188
1905.....	.....	8	14	49	23	2	.....	96
1906.....	.....	7	27	48	47	33	0	162
1907.....	.....	10	3	9	35	7	.....	64
1908.....	.....	6	32	26	11	7	1	83
1909.....	2	15	4	0	38	.....	.....	59
1910.....	.....	0	8	8	5	1	.....	22
1911.....	.....	3	14	119	133	88	.....	357
1912.....	.....	16	15	44	.....	.....	.....	75
1913.....	.....	2	15	8	19	1	.....	49
Averages.....	0.9	7.2	10.6	43.1	34.1	12.1	0.2	117.2

¹ Angot, Alfred. Sur un mode de classification des étés. *Annuaire de la Société météorol. de France, Paris, Décembre 1913, 61: 341-345.*

² See page 625, above.

Temperatures above 30°C.—The average annual value of the sums above 30°C. is 15; they vary from 0 in 1878, 1891, and 1913 to 99 in 1911. Although they vary pretty much in the same way as do the sums counted above 25°, there are appreciable differences in details.

In the year 1910, which gives the smallest sum above 25°, the temperature did not once reach 30°C., but the three other years, 1878, 1891, and 1913, when the same phenomenon occurred, rank much higher in the table of sums above 25°C. In the same way the year 1899 comes to stand third among the temperatures above 25° and only sixth among the temperatures above 30°.

From the point of view of classification of summers, this method gives results to a certain extent dependent upon the temperature selected for the lower or starting point. Evidently one may choose other than the limits 25° and 30° selected by the author; and one might very properly investigate the limit that best presents the relations between temperature and certain phenological phenomena. It is even probable that this limiting temperature differs according to the phenomenon considered; however, one may remark that there would be no considerable advantage in selecting a limit higher than 30°C. since this would greatly increase the number of years characterized by zero sums. On the other hand, if the limiting temperature is notably less than 25°C., the differences between the years will be greatly reduced, and one would more and more closely approach the results obtained by discussing the mean monthly maxima. It thus appears that one should seek to fix upon some temperature between 25° and 30° as the lowest limit proper for the study of different phenomena. In provisionally adopting 25°C. as the lower limit the results should not greatly differ from those that one would find by using a limit determined by means of a more thorough discussion.

TABLE 2.—Sums of maximum temperatures exceeding 30°C. at Parc Saint-Maur, Paris.

Year.	May.	June.	July.	August.	September.	Year.
1873.....		1.6	5.6	9.1		16.3
1874.....	1.6	1.9	34.3		3.8	41.6
1875.....		3.0		7.4		10.4
1876.....		2.3	5.4	28.3		36.0
1877.....		7.3	4.2	2.6		14.1
1878.....						2.5
1879.....				2.5		3.7
1880.....	2.2		1.5		0.0	
1881.....			42.0	1.5		43.5
1882.....				1.5		1.5
1883.....		0.2	0.3			0.5
1884.....		0.0	9.5	9.5		19.0
1885.....	0.4	3.5	0.6	1.5		6.0
1886.....			3.6	3.2	1.6	8.4
1887.....		0.8	9.9	4.0		14.7
1888.....		4.5		0.5		5.0
1889.....		0.3	0.2		0.1	0.6
1890.....		1.1	0.6	2.6		4.3
1891.....						
1892.....	4.8	0.7	0.6	14.7		20.8
1893.....		5.5	8.6	13.3		27.4
1894.....		0.2	5.4	1.6		7.2
1895.....				2.5	23.3	25.8
1896.....			4.0			4.0
1897.....		3.0		0.8		3.8
1898.....				21.2	5.8	27.0
1899.....		0.0	3.3	22.8	3.4	29.5
1900.....		1.5	41.1	2.5		45.1
1901.....		5.9	8.5	1.6		16.0
1902.....			5.5			5.5
1903.....		2.3	2.2		2.4	6.9
1904.....			24.7	5.1		29.8
1905.....			2.0	1.6		5.6
1906.....		3.1	6.1	6.7	8.1	24.0
1907.....				4.7		4.7
1908.....		1.5	0.4			1.9
1909.....	0.2			2.0		2.2
1910.....						
1911.....			29.9	40.9	28.5	99.3
1912.....	2.5	1.5	6.9			10.9
1913.....						
Averages.....	0.3	1.2	6.5	5.3	1.9	15.2

DROUGHT AT NEW YORK CITY.

By C. D. REED, Local Forecaster.

[Dated Weather Bureau, New York, N. Y., Oct. 31, 1914.]

From August 30 to October 15, 1914, inclusive, occurred one of the most notable droughts in the 44 years of record at this station, and the resulting general interest by the public inspired the preparation of this study of local droughts at New York. It may not be amiss to note that the inquiries included such a vague and irrational idea as that the drought might be caused by the European war, where the use of large quantities of explosives, perhaps by causing heavy rains, drew the atmospheric moisture from this city. This was akin to another unscientific idea, that because there was a drought in New York there must be one over most of the United States, which was of course untrue as rains were frequent and copious in the Lower Missouri and Middle Mississippi valleys and the Southwest, but about normal in other sections, except the Atlantic States where the drought was more or less prevalent.

One of the more frequent questions was, "Is not this the worst drought on record?" The difficulty in answering this question positively will be apparent from a study of Table 2, page 630-1, which shows that this drought held the record for least rainfall up to its twenty-fifth day; that it also held the record of minimum up to the forty-second to forty-seventh days of its continuance; and that the record for all other periods of duration was held by other droughts.

There are several factors that enter into the case aside from the minimum amount of rain in a given number of days, such as the amount and character of the precipitation during the 30 days preceding; the maximum number of consecutive days without or practically without precipitation; the frequency and quantity of the precipitation by which the drought is broken; and the season of the drought's occurrence.

With respect to the supply of water in lakes, reservoirs, and cisterns, drought is most effectually broken when there are a few heavy downpours, with a total sufficiently large to make up the accumulated deficiency; but with respect to most vegetation the breaking of a drought is quite effectual when there are several gentle showers, though they lack much of making up an accumulated deficiency. In the vicinity of New York City a prolonged drought at any time from March 1 to August 15 is injurious to all vegetation; and some vegetables may be injured as late as the last of October. Winter droughts are of importance mainly in regions where the water-supply is dependent upon storage in the form of snow in adjacent mountains.

Nineteen of the more notable droughts at this station were selected and arranged in Table 2 (p. 630) for comparison. In general only such periods were chosen as showed precipitation of 0.10 inch or less in 10 days; 0.20 in 20 days; 0.30 in 30 days, etc., the first 10 days being wholly or nearly without precipitation and no drought of less than 20 days being considered.

On each day, beginning with the first day of the drought, the current and accumulated amounts of precipitation are entered and the entries continued until a single heavy or several moderate rains have effectually broken the drought. The actual period of each drought is terminated when it begins to be broken, not when entirely broken. The entry 2T, means two days with traces of precipitation; 3T, three days with traces, etc.

By this method it becomes possible to classify the various droughts according to accumulated precipitation on

any day of duration chosen for comparison. The minimum amount of accumulated precipitation for all days of duration is entered at the foot of the columns. A careful study of Table 2 shows that out of the 19 droughts tabulated, eight hold all records for minimum precipitation for all days of duration up to 65; and that a given drought may hold the record for intermittent periods of duration, while other droughts fill in the gaps between periods, as was the case with the recent drought referred to in the second paragraph. The drought from October 11 to November 17, 1874, holds the record for minimum precipitation for 29 and 33 to 38 days of duration.

The drought of April 17-June 7, 1903, because of its duration of 52 days with 0.49 inch of rain on six days, and the time of the year, is probably the most severe drought at this station. The drought of September 15-October 27, 1879, in the table is arbitrarily terminated with the forty-third day; the succeeding record shows an accumulated precipitation of only 2.01 inches in 74 days, which is the least amount for that number of consecutive days at this station.

The preeminent droughty year was probably 1910, with three well-defined droughts of 40, 51, and 40 days, respectively, totaling 131 days, and all occurring within the crop season. However, the damaging effects were somewhat forestalled by the plenteous rains that preceded each droughty period.

A table has been compiled showing all periods of 10 or more consecutive days with less than 0.01 inch of precipitation for all years from 1871 to 1914. In making this tabulation, where a period covered portions of two months, the period was entered in the month having the

larger number of days involved in the drought; and where an equal number of days fell in each month the period was credited to the first month. A summary of this table appears herewith as Table 1.

TABLE 1.—Summary of droughts of 10 or more consecutive days during 44 years, 1871-1914.

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Total number..	3	7	9	13	12	11	11	9	19	23	16	7	140
Maximum duration:													
Days.....	14	24	14	17	17	13	17	16	28	20	15	15	.....
Year.....	1872	1872	1910	1903	1887	1898	1910	1894	1884	1886	1910	1877	.....

From this table October can well be called the month of droughts, with September a close second. In fact the longest, second longest, and third longest periods without appreciable precipitation are in September. The longest was 28 days, September 1-28, 1884, in which there were 3 days having traces. The next longest was 27 days, September 10-October 6, 1910, in which there were 4 days with traces. The next longest was 25 days, August 30-September 23, 1914, with two traces. The longest period without even a trace was 24 days, February 15-March 9, 1872.

Out of the 44 years only three, 1882, 1888, and 1907, had no 10-day periods with less than 0.01 inch of precipitation. The year having the greatest number is 1872, with seven periods, totaling 94 days; 1881 also had seven periods, but they totaled only 76 days; and 1910 had six periods, totaling 95 days.

TABLE 2.—Principal droughts at New York, N. Y., during the years 1871-1914.

Year.	Period.			Precipitation.				Accumulated precipitation, beginning with first day of drought and continuing till drought is broken.																						
	Began.	Ended.	Days.	Consecutive days with less than 0.01 inch.		Total.	Number of days with 0.01 inch or more.	Total during 30 days preceding.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
				Number of days.	Number of traces.																									
1872....	Feb. 15	Mar. 9	24	24	0	0	1.97	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1874....	Aug. 26	Sept. 15	21	21	1	T.	0	3.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1874....	Oct. 11	Nov. 19	40	19	0	.36	4	9.02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01
1877....	Dec. 7	Jan. 31	28	15	3	.14	2	4.63	0	0	0	0	0	0	0	0	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
1879....	Sept. 15	Oct. 27	43	10	1	.36	10	5.08	0	0	0	0	0	0	0	0	0	T.	T.	T.	T.	T.	T.	T.	T.	T.	T.	T.	T.	T.
1881....	Aug. 8	Sept. 9	33	10	0	.11	5	2.34	0	T.	T.	T.	T.	T.	T.	T.	T.	T.	T.	T.	T.	T.	T.	T.	T.	T.	T.	T.	T.	T.
1884....	Sept. 1	Oct. 21	51	28	3	.43	6	8.56	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1886....	Aug. 8	Sept. 8	32	13	1	.26	5	3.49	.01	0.01	0.01	0.01	0.01	0.01	0.05	0.5	.06	.07	.07	.07	.07	.07	.07	.07	.07	.07	.07	.07	.07	.07
1886....	Sept. 24	Oct. 26	33	20	0	.30	3	1.98	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1887....	Apr. 30	May 25	26	17	3	.13	1	3.67	0	0	0	0	0	0	0	0	0	T.	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13
1901....	Oct. 15	Nov. 23	40	18	2	.26	5	3.17	T.	T.	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
1903....	Apr. 17	June 7	52	17	1	.49	6	4.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1905....	Oct. 26	Nov. 27	33	11	2	.17	4	2.67	T.	T.	T.	T.	T.	T.	T.	T.	T.	.03	.03	.03	.11	.11	.11	.11	.11	.11	.11	.11	.11	.11
1908....	Sept. 7	Oct. 25	49	21	1	.98	6	5.74	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1909....	Oct. 28	Nov. 22	26	14	2	.11	2	1.29	0	0	0	0	0	0	0	0	0	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03
1910....	Mar. 8	Apr. 16	40	14	2	.51	6	4.54	T.	2T.	2T.	2T.	2T.	.05	.05	.05	.05	.20	.20	.20	.25	.25	.25	.25	.25	.25	.25	.25	.25	.25
1910....	June 19	Aug. 8	51	17	2	.59	8	5.91	0	0	0	0	0	0	0	0	0	T.	T.	T.	T.	T.	T.	T.	T.	T.	T.	T.	T.	T.
1910....	Sept. 10	Oct. 19	40	27	4	.34	2	2.01	0	0	0	0	0	0	0	0	0	T.	T.	T.	T.	T.	T.	T.	T.	T.	T.	T.	T.	T.
1914....	Aug. 30	Oct. 15	47	25	2	.26	3	2.18	T.	T.	T.	T.	T.	T.	T.	T.	T.	2T.	2T.	2T.	2T.	2T.	2T.	2T.	2T.	2T.	2T.	2T.	2T.	2T.
Minimum.....									0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TABLE 2.—Principal droughts at New York, N. Y., during the years 1871-1914—Continued.

Year.	Period.			Accumulated precipitation, beginning with first day of drought and continuing till drought is broken—Continued.																						
	Began.	Ended.	Days.	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	
1872....	Feb. 15	Mar. 9	24	0	0	0	1.58																			
1874....	Aug. 26	Sept. 15	21	0.96																						
1874....	Oct. 11	Nov. 19	40	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.10	0.36	0.36	0.59	0.59	0.62	
1877....	Dec. 7	Jan. 31	28	0.02	0.02	0.14	0.14	0.14	0.14	0.14	0.75															
1879....	Sept. 15	Oct. 27	43	0.06	0.06	0.06	0.06	0.06	0.11	0.12	0.12	0.12	0.12	0.12	0.12	0.13	0.21	0.21	0.27	0.32	0.36	0.36	0.36	0.36	0.36	
1881....	Aug. 8	Sept. 9	33	0.09	0.09	0.09	0.09	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.45	0.47	1.27							
1884....	Sept. 1	Oct. 21	51	T.	2T.	3T.	3T.	3T.	3T.	3T.	3T.	0.11	0.15	0.15	0.28	0.31	0.31	0.31	0.31	0.32	0.32	0.32	0.32	0.43	0.43	
1886....	Aug. 8	Sept. 8	32	0.07	0.07	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.50	0.50	1.64								
1886....	Sept. 24	Oct. 26	33	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.30	3.01									
1887....	Apr. 30	May 25	26	0.13	0.13	0.13	0.13	0.13	0.48	0.49	0.99															
1901....	Oct. 15	Nov. 23	40	0.04	0.04	0.04	0.04	0.04	0.04	0.13	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.26	1.22			
1903....	Apr. 17	June 7	52	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.24	0.24	0.32	0.32	0.32	0.32	0.32	0.33	0.33	
1905....	Oct. 26	Nov. 27	33	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.81	1.67								
1908....	Sept. 7	Oct. 25	49	0.45	0.70	0.70	0.70	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.93	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	
1909....	Oct. 28	Nov. 22	26	0.11	0.11	0.11	0.11	0.11	0.42	1.05	1.46															
1910....	Mar. 8	Apr. 16	40	0.25	0.25	0.25	0.25	0.25	0.25	0.45	0.46	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	1.23	1.70	2.25	
1910....	June 19	Aug. 8	51	0.06	0.06	0.06	0.06	0.06	0.06	0.09	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.20	0.29	
1910....	Sept. 10	Oct. 19	40	4T.	4T.	4T.	4T.	4T.	4T.	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.34	0.34	0.34	0.34	0.34	3.38			
1914....	Aug. 30	Oct. 15	47	2T.	2T.	2T.	2T.	0.09	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	
Minimum				0	0	0	2T.	3T.	3T.	3T.	0.01	0.02	0.02	0.02	0.02	0.06	0.06	0.06	0.06	0.06	0.10	0.18	0.18	0.18	0.20	0.20

Year.	Period.			Accumulated precipitation, beginning with first day of drought and continuing till drought is broken—Continued.																						
	Began.	Ended.	Days.	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	
1872....	Feb. 15	Mar. 9	24																							
1874....	Aug. 26	Sept. 15	21																							
1874....	Oct. 11	Nov. 19	40	1.76																						
1877....	Dec. 7	Jan. 31	28																							
1879....	Sept. 15	Oct. 27	43	0.64	0.64	0.64	0.64	0.64	0.68	0.76	0.76	0.77	1.13	1.13	1.13	1.13	1.13	1.27	1.30	1.30	1.39	1.40	1.40	1.40	2.01	
1881....	Aug. 8	Sept. 9	33																							
1884....	Sept. 1	Oct. 21	51	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	1.23														
1886....	Aug. 8	Sept. 8	32																							
1886....	Sept. 24	Oct. 26	33																							
1887....	Apr. 30	May 25	26																							
1901....	Oct. 15	Nov. 23	40																							
1903....	Apr. 17	June 7	52	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.49	0.62	0.77	0.83	0.83	2.76									
1905....	Oct. 26	Nov. 27	33																							
1908....	Sept. 7	Oct. 25	49	0.94	0.94	0.94	0.94	0.94	0.98	1.80																
1909....	Oct. 28	Nov. 22	26																							
1910....	Mar. 8	Apr. 16	40																							
1910....	June 19	Aug. 8	51	0.29	0.29	0.47	0.52	0.52	0.52	0.52	0.59	1.32	1.84													
1910....	Sept. 10	Oct. 19	40																							
1914....	Aug. 30	Oct. 15	47	0.20	0.20	0.20	0.26	1.96																		
Minimum				0.20	0.20	0.20	0.26	0.33	0.33	0.33	0.33	0.49	0.62	0.77	0.83	0.83	1.13	1.27	1.30	1.30	1.39	1.40	1.40	1.40	1.40	2.01

1878.

NOTES ON ICE AND MERCURY.

Three recent memoirs have been published in the Transactions of the Royal Society of Canada on subjects of importance in meteorology. From these we make the following extracts:

1. *The crushing strength of ice* (by H. T. Barnes).¹—The crushing strength of ice varies according to its temperature, ranging between 358 and 1,128 pounds per square inch. The average in all directions relative to the freezing surface of the water is 363 pounds to the square inch.

2. *The expansive force of ice* (by H. T. Barnes, J. W. Hayward, and Norman McLeod).²—"As a result of our study of ice expansion, which must be regarded as only preliminary, we find that (a) The crushing strength of ice is most probably 400 pounds per square inch, or 28 kgms. per square centimeter; (b) an ice block will yield under pressure at approximately 200 pounds per square inch, which is probably due to the slipping of the crystals; (c) an ice sheet will form cracks on the upper and under surface due to unequal strain; (d) that a permanent expansion may result if the cracks become filled and frozen; (e) according to the most trustworthy results of other observers, the ice frozen to concrete develops its full crushing strength, and the tensile strength of ice is under 200 pounds per square inch."

¹Transactions, Royal Society of Canada, Ottawa, 1914 (3) 8: 19-22.
²Transactions, Royal Society of Canada, Ottawa, 1914 (3) 8: 29-49.

3. *Coefficient of expansion of mercury at low temperatures* (by C. B. James).³—"Taking the mean value, we find:

Temperature range.	Coefficient uncorrected.	Coefficient corrected.
-20 to 0° C.	0.00017962	0.00018059
-30 to 0° C.	0.000179389	0.00018030
-37 to 0° C.	0.000179005	0.00017988

Temperature range.	Callendar and Moss.	Callendar and Harlow.	James.
0 to 100° C.	0.000182054	0.00018244	0.00018241
-20 to 0° C.	0.000180317		0.00018059
-30 to 0° C.	0.00018025		0.00018030
-37 to 0° C.	0.0001801		0.000179881

³ Extrapolated from formula.

"It will be seen that we are in good agreement with the determination of the quartz dilatometer of Callendar and Harlow, but disagree with the determination of Callendar and Moss. The last three results of Callendar and Moss are extrapolated values from Callendar and Moss formula which was deduced from observations extending to -10° C. only.

"Our results do not show any very large change in the coefficient although it falls off more rapidly than the extrapolation formula of Callendar."

³Transactions, Royal Society of Canada, Ottawa, 1914 (3) 8: 51-58.

**METEOROLOGICAL OBSERVATIONS IN GERMANY NOT
SUSPENDED.**

A letter dated Berlin, November 30, 1914, received from Geheimer Regierungs-Rat Prof. Dr. Gustav Hellman, director of the Royal Prussian Meteorological Institut in Berlin, advises us that the usual regular observations are being maintained without interruption throughout the German Empire. So far as the domestic weather forecasts for Germany are dependant upon cable reports

from foreign countries, they are made with difficulty; all such reports are at present interrupted, even those from Iceland since the latter come over a Danish cable that lands at Aberdeen, where they are suppressed and are not permitted to reach even Copenhagen.

The regular, though belated, arrival of the *Meteorologische Zeitschrift*, and other scientific publications shows that the German scientific world continues its activity and is but slightly affected by the war.—[C. A. jr.]

SECTION III.—FORECASTS.

STORMS AND WARNINGS FOR NOVEMBER.

By ALFRED J. HENRY, Professor of Meteorology.

[Dated, Washington, D. C., Dec. 4, 1914.]

A count of the lows that have occurred during November in the 10 years 1900–1909, classed according to their point of origin, gives the following results: Alberta, 38; North Pacific, 22; South Pacific, 8; Northern Rocky Mountain region, 7; Middle Rocky Mountain region, 14; Texas, 10; East Gulf, 4; South Atlantic, 3; Central Valley, 13; total, 119, or an average of 12 per year, of which the great majority belong to the Alberta and North Pacific groups.

The movement of highs and lows during November, 1914, was typical of this month in practically all respects. Twelve primary and two secondary lows were charted, classed as follows: Alberta, 8; North Pacific, 2; South Pacific, South Atlantic, and Texas, 1 each. All of the lows charted reached the Atlantic except South Pacific No. V, and Alberta No. XII.

The movement of the Alberta and North Pacific lows was along the northern boundary, passing generally north of the Lake region and thence down the St. Lawrence Valley. The paths of six Alberta lows on Chart III are combined in the one path shown by the heavy line along the northern border.

The weather of the month was dominated almost wholly by the Alberta lows, and, as a consequence, clear skies, much bright sunshine, relatively high day temperatures, and lack of precipitation were the characteristic features. South Pacific low No. V and Texas low No. XI gave an abundance of rain along the Gulf coast. The South Atlantic States also had normal rains for the month.

One of the most interesting features of the month was the decay of Alberta low No. VIII, in the upper Lake region and the synchronous development of a low over the Atlantic, off Hatteras, on the morning of the 19th (see track No. IX), which gave New England its first "northeaster" of the season. It may be remembered that somewhat similar development gave the Lake region its destructive November storm just about a year ago. The rapid fall in pressure over northern Alabama, northern Georgia, and eastern Tennessee, on the afternoon of the 19th, caused a secondary depression to form in the vicinity of Asheville, N. C., at 8 p. m. of the 19th. This secondary depression, in connection with high area No. VI, caused a rapid and record-breaking (for November) fall in temperature that was pretty general over the Southeastern States, except Florida. The last-named State was visited by killing frost as far south as Tampa on the morning of the 21st.

RAPID MOVEMENT OF LOW CENTERS.

As will be seen by reference to Chart No. III of this REVIEW, there were several cases during the month when the low center was translated in an easterly direction at the very high speed of 60 to 80 miles per hour. (See No. IV, p. m. map of the 11th, to a. m. map of 12th; No. XI, a. m. to p. m. of the 26th.) In both of these cases the pressure gradient to the eastward of the low center was very slight and the trend of the isobars was favorable to a rapid eastward movement, viz, parallel with the course of the low. The 12-hour pressure fall, concurrent with the initial position of the low center, was fairly well marked and extended in each case a little beyond the positions of the lows at the end of the ensuing 12-hour period.

It is not to be inferred that the system of whirling winds of which the low is composed was translated bodily across country at the speeds mentioned. We prefer to believe that the mode of progression of a low consists in a steady and continuous fall in pressure far in its front and a somewhat sharper rise in pressure in the rear; that the advance is somewhat analogous to the progression of a wave in water.

SLOW-MOVING LOWS IN NOVEMBER.

The South Pacific low charted as No. V had several periods of stagnation in its course, viz, at its point of origin near the mouth of the Rio Grande River, and in the Gulf of Mexico, off the mouth of the Mississippi, on the 14th. The indicated track, afternoon of 14th to morning of 15th, is uncertain. A later West Gulf storm, No. XI, stagnated near New Orleans for about 48 hours and finally became extinct.

It seems probable that the further movement of this storm, as well as that of No. XIV, an Alberta storm which expired on the same date, over Saskatchewan, was prohibited by high area No. VIII, which on that date was centered off the New England coast.

The history of this area of high pressure, No. VIII, shows that in the 24 hours ending with 8 p. m. of November 28 sea-level pressure within the closed isobar at its center increased from 30.40 to 30.70 inches and that, coincident with the increase in pressure, there was a reduction in the speed of its eastward movement from about 40 miles per hour to less than 10 miles per hour. It caused easterly winds to prevail over Atlantic coast districts, and these latter in turn produced a general cloud blanket that extended as far inland as the Mississippi Valley and was by far the most extensive area of cloud that prevailed during the month. The total cessation of the easterly drift of the lower layers of the atmosphere, apparently produced by the high in question, was one of the interesting features of the month.

SECTION IV.—RIVERS AND FLOODS.

RIVERS AND FLOODS, NOVEMBER, 1914.

By ALFRED J. HENRY, Professor of Meteorology, in charge of River and Flood Division.

[Dated: Washington, Dec. 26, 1914.]

The month was devoid of flood-producing rains in all parts of the country save in the South Atlantic States where moderately heavy and continuous rains for nearly 48 hours on the 14th and 15th and again on the 29th and 30th caused the streams to rise sharply, but in practically all cases the rise stopped a little short of the flood stage. No damage by high water was done.

SNOW SURVEY ON COTTONWOOD CREEK, IDAHO.

In March, 1914, a snow survey on the headwaters of Cottonwood Creek, Idaho, was made, under the direction of Section Director E. L. Wells, of Boise, Idaho.

The daily discharge of Cottonwood Creek from March 7 to September 30, is now available, through cooperation with the Water Resources Branch of the United States Geological Survey. The snow survey above-mentioned showed that in the early part of March snow water was present in the following amounts:

	Acre feet.
Below 4,000 feet.....	401.5616
4,000-5,000 feet.....	5,212.1344
5,000-6,000 feet.....	6,531.0720
Above 6,000 feet.....	3,098.9312
Total.....	15,243.6992

Mr. Wells says "The watershed is rather scantily forested and yet there are probably enough trees to affect the snow supply somewhat, though just what allowance should be made is difficult to say." The records of the gaging station above-mentioned show that the total discharge March 7 to September 30, 1914, was 9,710 acre feet, or 64 per cent of the amount of snow water on the watershed in March."

The precipitation subsequent to the date of the snow survey, as measured at a point in the lower portion of

the watershed, aggregated for the period in question 7.17 inches. Mr. Wells estimates that the precipitation of the entire watershed was 50 per cent greater than this amount, or 10.76 inches, which is equivalent to 15,149 acre feet for the watershed. Since, however, the great bulk of the precipitation was in the form of small showers, generally less than a quarter of an inch—in the seven months there were but six showers that gave 0.40 inch or more—so that the effective precipitation must have been only about 4,000 acre-feet. This, added, to the snow water present in March, gives a total of 19,444 acre-feet. The measured discharge, as before stated, was 9,710 acre-feet, or less than 50 per cent of the approximate amount of snow water plus the precipitation March to September, inclusive. The uncertain quantities in the above computations are: (1) The amount of snow water that evaporated; and (2) the run-off from the summer rainfall. The fact that the latter was mostly in the form of light showers makes it improbable that any considerable amount found its way into the stream.—[A. J. H.]

MEAN LAKE LEVELS DURING NOVEMBER, 1914.

By UNITED STATES LAKE SURVEY.

[Dated: Detroit, Mich., Dec. 4, 1914.]

The following data are reported in the "Notice to Mariners" of the above date:

Data.	Lakes.			
	Superior.	Michigan-Huron.	Erie.	Ontario.
Mean level during November, 1914:				
Above mean sea level at New York.....	602.45	579.92	571.44	245.25
Above or below—				
Mean stage of October, 1914.....	—0.30	—0.36	—0.66	—0.34
Mean stage of November, 1913.....	—0.43	—0.55	—0.83	—0.81
Average stage for November, last 10 years.....	—0.09	—0.47	—0.43	—0.49
Highest recorded November stage.....	—1.06	—3.00	—2.23	—2.57
Lowest recorded November stage.....	—0.95	—0.74	—0.74	—1.84
Probable change during December, 1914.....	—0.2	—0.2	—0.1	—0.1

SECTION V.—BIBLIOGRAPHY.

RECENT ADDITIONS TO THE WEATHER BUREAU LIBRARY.

C. FITZHUGH TALMAN, Professor in charge of Library.

The following have been selected from among the titles of books recently received as representing those most likely to be useful to Weather Bureau officials in their meteorological work and studies:

- Alcobé y Arenas, Eduardo.**
El clima de Barcelona. Resumen climatológico del primer decenio del siglo XX (años de 1901 a 1910 inclusive), según los datos registrados en el Observatorio meteorológico de la Universidad de Barcelona. Barcelona. 1914. 42 p. 6 pls. 4°. (Memorias de la Real academia de ciencias y artes de Barcelona, 3ª época, v. 11, núm. 10.)
- Barnes, H. T.**
The crushing strength of ice. Ottawa. 1914. 19-22 p. 2 pl. 8°. (From the Transactions of the Royal society of Canada, 3d ser., 1914, v. 8.)
- Barnes, H. T., Hayward, J. W., & McCleod, Norman.**
The expansive force of ice. Ottawa. 1914. 29-49 p. 8°. (From the Transactions of the Royal society of Canada, 3d ser., 1914, v. 8.)
- Cramp, William.**
Some notes on the measurement of air velocities, pressures and volumes. Manchester. 1914. 16 p. 8°. (From v. 58, pt. 2, of Memoirs and proceedings of the Manchester literary and philosophical society, sess. 1913-14.)
- Eredia, Filippo.**
La nebulosità in Italia. Roma. 1914. 38 p. f°. (Estratto dagli Annali del R. Ufficio centrale di meteorologia e geodinamica, v. 35, parte 1, 1913.)
- Eredia, Filippo, & Castro, L. de.**
Sulla climatologia dell' Etiopia. Roma. 1914. 44 p. 8°. (Estratto dal Bollettino della Reale società geografica, fasc. 8, 1914, p. 845-884.)
- France. Service hydrométrique du Bassin de la Seine.**
Observations sur les cours d'eau et la pluie, centralisées pendant l'année 1912-13. [Paris. 1914.] 7 charts. f°. Résumé des observations centralisées pendant l'année 1912-13. Paris. 1914. 21 p. f°.
- Hamburg. Deutsche Seewarte.**
Schlüssel zu den Wettertelegrammen der deutschen meteorologischen Stationen an die Deutsche Seewarte, nebst Angabe der deutschen Abonnement-Wettertelegramme. [Hamburg. 1914.] 6 p. 4°.
- Hann, Julius v.**
Meteorologie von Fernando de Noronha, einer kleinen ozeanischen äquatorialen Insel. Wien. 1914. 46 p. 8°. (Aus den Sitzungsberichten der Kaiserl. Akademie der Wissenschaften in Wien, Mathem.-naturw. Klasse, Bd. 123, Abt. IIa, Juni 1914.)
- Hunt, Henry A., Taylor, Griffith, & Quayle, E. T.**
The climate and weather of Australia. Melbourne. 1913. 93 p. plates. 8°. (Australia. Commonwealth bureau of meteorology. [Publication.])
- International institute of agriculture.**
Rapport pour l'Assemblée générale de 1913 sur la question n. 7 du programme concernant la météorologie agricole. Avec annexes. Rapporteur: Louis-Dop. Rome. 1913. 135 p. 8°. Rapport pour l'Assemblée générale de 1913 sur la question n. 9ª du programme concernant l'assurance contre les risques de la grêle. Rapporteur: O. Bolle. Rome. 1913. iv, 38 p. 8°.
- Jameson, P. R.**
The thermometer and its family tree. Rochester, N. Y. [c1914.] 24 p. 12°. (Published by the Taylor instrument companies.)
- Manley-Bendall.**
Il servizio meteorologico degli Stati Uniti . . . Traduzione di Giovanni Magrini. Venezia. 1914. 39 p. plates. 4°. (Venice. Ufficio idrografico. Pubblicazione n. 59.)
- Perret, Robert.**
La géographie de Terre-Neuve. Paris. 1913. vi, 372 p. plates. 8°. [Chap. iv: Le climat.]

- Pettersson, O.**
Studien in der Geophysik und der kosmischen Physik. (Vorläufige Mitteilung.) Berlin. [1914.] 31 p. 4 pl. 4°. (S. A. Annalen der Hydrographie usw., herausg. von der Deutschen Seewarte in Hamburg, 1914, Band 42, Heft 3 bis 5.)
- Stok, J[oh]. P[aulus] van der.**
On the relation between the cloudiness of the sky and the duration of sunshine. [Amsterdam.] 1913. 15 p. 4°. (Reprinted from: K. Akademie van wetenschappen te Amsterdam. Proceedings of the meeting of Saturday, November 29, 1913, v. 16, p. 507-521.)
The treatment of frequencies of directed quantities. [Amsterdam.] 1914. 12 p. 4°. (Reprinted from: K. Akademie van wetenschappen te Amsterdam. Proceedings of the meeting of Saturday, September 26, 1914, v. 17, p. 586-597.)
- Tuttle, Charles R.**
Alaska; its meaning to the world; its resources; its opportunities. Seattle. 1914. 318 p. plates. 8°. [Climate, p. 117-124; also scattered references.]
- Venice. Ufficio idrografico.**
Carta annuale delle piogge nella regione veneta per il 1913. Venice. 1914. 50 p. map. 4°. (Pubblicazione n. 61.)
- Wallén, Axel.**
Om afduktbestämningar. Stockholm. 1914. 6 p. f°. (Sweden. Hydrografiska byrån. [Publication.] Särtryck ur Teknisk tidskrift, Vag- och vattenbyggnadskonst 1914, häft 10.)
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RECENT PAPERS BEARING ON METEOROLOGY AND SEISMOLOGY.

C. FITZHUGH TALMAN, Professor in charge of Library.

The subjoined titles have been selected from the contents of the periodicals and serials recently received in the Library of the Weather Bureau. The titles selected are of papers and other communications bearing on meteorology and cognate branches of science. This is not a complete index of the meteorological contents of all the journals from which it has been compiled. It shows only the articles that appear to the compiler likely to be of particular interest in connection with the work of the Weather Bureau.

- Aeronautical journal.* London. v. 18. October, 1914.
- Hankin, E. H.** Atmospheric rotary movements of small extent. p. 344-353.
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- Shelford, V. E.** The significance of evaporation in animal geography. p. 29-43.
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- Royal astronomical society of Canada. Journal.* Toronto. v. 8. September-October, 1914.
- Steadworthy, A.** Spectrum of lightning. p. 345-348.
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- Barnes, Howard T.** Icebergs and their location in navigation. p. 523-542. (pt. 2.)
- Cave, Charles J. P.** The winds in the free air. p. 717-726. (pt. 3.)

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SECTION VI.—WEATHER AND DATA FOR THE MONTH.

THE WEATHER OF THE MONTH.

By P. C. DAY, Climatologist and Chief of Division.

Pressure.—The distribution of the mean atmospheric pressure over the United States and Canada, and the prevailing direction of the winds, are graphically shown on Chart VII, while the average values for the month at the several stations, with the departures from the normal, are shown in Tables I and III.

The mean pressure for the month as a whole was above the normal over the greater portion of the country, the plus departures being rather marked over the western part of the Plains region and most of the Rocky Mountain districts. In New England and thence westward over the northern border States to Montana the means were somewhat less than the normal for the month, as was also the case in much of California, while in the Gulf States the monthly pressure was about normal.

At the beginning of the month high barometric pressure prevailed generally, save in the far Northwest and in the region of the Great Lakes, where readings were comparatively low, but during the first decade relatively low pressure was the rule in most northern districts with higher readings to the southward. During the first half of the second decade barometric changes were rather marked, but soon after the middle of the month high pressure again prevailed quite generally. Pressure was markedly low over New England about the close of the second decade, but this depression moved rapidly to sea and relatively high readings again were the rule over much of the country during the remainder of the month.

The distribution of the highs and lows was such as to favor the frequent occurrence of westerly winds over northern districts from the Rocky Mountains eastward to New England and winds from a southerly direction in the great central valleys; elsewhere variable winds prevailed.

Temperature.—At the beginning of the month moderately warm weather prevailed in all districts, with a tendency to higher temperatures during the following few days in the central valleys. With only slight variations warm weather for the season continued over nearly all portions of the country until about the middle of the month.

By the morning of the 16th a well developed cold wave had overspread the Plains region, and the first zero temperatures of the year were reported. This cold wave rapidly overspread the central valleys and the Gulf States during the following few days, causing freezing temperatures almost to the Gulf and South Atlantic coasts. Following closely upon this period of low temperatures, a second cold wave moved rapidly from the Northwest, reaching the central valleys by the 19th and the Gulf and South Atlantic States during the 20th and 21st, at which time some of the lowest November temperatures ever recorded in those districts were reported. Freezing temperatures reached the coast lines of the southeastern States and extended well into central Florida, and light frost was reported as far south as Miami in that State.

With the disappearance of the above mentioned cold wave off the South Atlantic coast about the 24th, warmer weather became general and the last week of

the month was unusually warm for the season over northern and central districts and moderately warm over practically all other portions of the country.

For the month as a whole the average temperature, as in the preceding month, was above the normal in all districts save for a few points in the southeastern States, along the New England coast and on the coasts of Oregon and northern California, where the means were normal or slightly below.

Maximum temperatures were high over the central portions of the country from the Atlantic to the Pacific on several dates during the first week of the month, the readings at a number of points being as high as or higher than had previously been observed in November. Minimum temperatures were unusually low on the 20th and 21st over the east Gulf and South Atlantic States, but otherwise they were within the limits of previous years.

Precipitation.—The month opened with generally settled weather conditions and clear skies prevailing, save for precipitation in the far Northwest, and local showers in the region of the Great Lakes. The north Pacific storm area moved eastward over the more northern districts, reaching the St. Lawrence Valley about the 5th, but over the central and southern portions of the country fair weather continued. On the morning of the 9th a disturbance had appeared off the South Atlantic coast, and rains had fallen quite generally from the Mississippi River eastward, with general thunderstorms in the Southeastern States. By the following day, however, this disturbance had disappeared from the field of observation and fair weather had again become general in all portions of the country.

Early in the second decade a storm area advanced from the Canadian Northwest, reaching the Lake region, attended by high winds, rain, and snow, about the 13th. At the same time another disturbance of considerable magnitude was advancing from the far Northwest, and a moderate depression had appeared in the Gulf of Mexico, resulting during the following few days in the occurrence of precipitation over much of the country, with some especially heavy falls at points along the Gulf coast. By the 17th the last of these disturbances had passed to sea and fair weather prevailed generally.

On the morning of the 19th a shallow depression appeared off the South Atlantic coast, which advanced and coalesced with a disturbance that was moving eastward over the Lake region, forming a marked storm over New England the following day, attended by heavy snow in the interior of New England and northern New York and rain on the coast.

During the first few days of the third decade fair weather prevailed quite generally, but rain set in over the Southwest about the 23d and spread slowly eastward and northeastward during the latter half of the decade, covering most districts east of the Mississippi River by the end of the month, some heavy falls again occurring in portions of the Gulf States.

For the month as a whole precipitation was scanty and largely deficient over most of the country. In the Ohio Valley the monthly totals were but little over an inch, while in the upper Mississippi Valley and from the central and northern Plains States westward to and in-

cluding the Plateau region the precipitation for the month was generally negligible, large areas in those districts receiving no measurable amounts. In Tennessee and over the Atlantic coast States from Virginia northward the precipitation was likewise markedly deficient, as was also the case over the Pacific coast States, except locally along the coast of Washington where the amounts were somewhat more than normal. However, over most of the Gulf States the rainfall for the month was generous, amounting to from 4 to 5 inches, while small areas near the coast received excessive falls, as did also the southeastern coast of Florida, points in the southern Appalachian region, and the lower Rio Grande Valley.

GENERAL SUMMARY.

The month as a whole was marked by an unusual amount of warm, sunshiny weather in all districts, and a decided shortage in precipitation over much of the interior and western portions of the country.

Over the principal corn-growing States the warm dry weather permitted the gathering of the crop in excellent condition and the work was nearing completion in most districts, although the dry condition of the fodder delayed progress in some sections.

In the principal winter grain-growing districts the weather was fairly favorable for fall-sown grain, although at the close of the month rain was needed in many sections, especially in the central and southern districts to westward of the Mississippi River and in portions of the far Northwest.

In the cotton region the weather was favorable for picking and this work was largely completed during the month while other activities progressed satisfactorily, especially in the western districts, where the absence of frost and ample precipitation were very favorable for the trucking interests.

The severe cold over the southeastern districts near the end of the second decade did considerable damage to the trucking interests of that section, especially in the southern portions of Alabama and Georgia and in northern and central Florida, but the citrus interests of the last-named State escaped serious loss.

The dry weather over the interior and western districts greatly hindered the growth of fall pasturage, and the water supply in portions of the Ohio Valley and surrounding districts was becoming low at the end of the month, but the absence of snow over the great western ranges was favorable for continued grazing.

At the end of the month but little snow had fallen in the mountain districts of the West, and elsewhere the ground was free of snow, except in portions of New England, where small amounts were reported.

Average accumulated departures for November, 1914.

Districts.	Temperature.			Precipitation.			Cloudiness.		Relative humidity.	
	General mean for the current month.	Departure for the current month.	Accumulated departure since Jan. 1.	General mean for the current month.	Departure for the current month.	Accumulated departure since Jan. 1.	General mean for the current month.	Departure from the normal.	General mean for the current month.	Departure from the normal.
	° F.	° F.	° F.	Inches	Inches	Inches	P. ct.	P. ct.	P. ct.	P. ct.
New England.....	39.2	-0.1	-6.4	2.54	-1.00	-6.10	6.0	+0.2	70	-8
Middle Atlantic.....	44.3	+0.5	+1.4	1.91	-1.00	-8.00	4.8	-0.5	65	-10
South Atlantic.....	53.8	-0.3	+4.0	3.42	+0.40	-11.70	4.1	-0.4	69	-9
Florida Peninsula.....	64.0	-0.4	-5.2	3.81	+1.60	-9.40	6.2	+1.7	76	-4
East Gulf.....	55.8	0.0	-2.6	2.89	+1.30	-3.00	4.6	0.0	71	-5
West Gulf.....	58.4	+2.0	-8.9	3.82	+0.70	-4.70	5.5	+0.9	74	0
Ohio Valley and Tennessee.....	46.6	+1.6	+6.6	1.45	-2.00	-8.20	4.6	-1.1	64	-9
Lower Lakes.....	39.9	+0.8	-3.6	1.65	-1.40	-3.00	6.9	-0.4	71	-6
Upper Lakes.....	26.3	+1.7	+11.5	1.74	-0.70	-1.20	6.7	-0.4	78	-2
North Dakota.....	31.9	+7.4	+29.8	0.40	-0.40	+2.30	5.1	-0.3	74	-5
Upper Mississippi Valley.....	42.9	+5.2	+24.8	0.48	-1.50	-4.30	4.4	-0.9	68	-6
Missouri Valley.....	45.0	+7.5	+33.1	0.16	-1.10	-0.50	3.6	-1.2	60	-11
Northern slope.....	39.1	+7.0	+25.9	0.21	-0.50	-1.80	5.4	+0.6	61	-6
Middle slope.....	48.4	+6.6	+28.7	0.18	-0.80	-4.10	2.7	-1.2	58	-4
Southern slope.....	54.0	+3.0	+10.8	1.88	+0.70	+5.90	4.0	-1.2	70	+8
Southern Plateau.....	52.7	+3.8	+7.5	0.52	+0.10	-0.40	2.4	-0.4	53	+10
Middle Plateau.....	41.0	+1.4	+12.2	0.07	-0.80	-0.40	2.4	-1.5	47	-11
Northern Plateau.....	41.5	+2.9	+21.9	0.59	-0.30	-0.90	6.4	+0.6	63	-11
North Pacific.....	46.7	+1.6	+17.2	7.44	+0.10	+3.10	8.2	+0.7	86	+2
Middle Pacific.....	55.2	+2.2	+7.7	1.04	-2.10	-2.80	2.9	-1.6	64	-11
South Pacific.....	62.7	+5.6	+21.9	0.32	-1.00	+2.20	3.1	-0.2	58	-9

Maximum wind velocities, November, 1914.

Stations.	Date.	Velocity.	Direction.	Stations.	Date.	Velocity.	Direction.
		mi./hr.				mi./hr.	
Alpena, Mich.....	3	52	se.	New York, N. Y....	17	50	nw.
Block Island, R. I....	19	58	ne.	Do.....	20	55	nw.
Buffalo, N. Y.....	1	52	sw.	Do.....	23	50	nw.
Do.....	4	60	sw.	North Head, Wash..	1	62	s.
Do.....	13	84	sw.	Do.....	2	56	s.
Do.....	16	56	w.	Do.....	12	84	s.
Do.....	17	66	w.	Do.....	13	58	w.
Do.....	25	54	sw.	Do.....	22	58	s.
Do.....	26	59	sw.	Do.....	27	54	se.
Do.....	27	54	sw.	Pensacola, Fla.....	27	62	se.
Canton, N. Y.....	4	60	w.	Do.....	28	60	se.
Do.....	13	59	sw.	Point Reyes Light, Cal.....	2	60	nw.
Cleveland, Ohio.....	13	50	w.	Do.....	5	52	nw.
Eastport, Me.....	13	52	s.	Do.....	13	64	nw.
Do.....	20	55	ne.	Do.....	14	50	nw.
Grand Haven, Mich..	17	53	w.	Do.....	30	66	s.
Hatteras, N. C.....	15	56	se.	Providence, R. I....	2	50	nw.
Lander, Wyo.....	13	74	sw.	Do.....	15	50	se.
Mount Tamalpais, Cal.....	1	55	nw.	Seattle, Wash.....	13	64	sw.
Do.....	13	60	nw.	Syracuse, N. Y.....	13	50	w.
Do.....	30	60	sw.	Tatoosh Island, Wash.....	2	50	s.
Mount Weather, Va..	8	56	nw.	Do.....	3	53	s.
Do.....	16	74	nw.	Do.....	4	52	s.
Do.....	17	50	w.	Do.....	8	61	s.
Do.....	20	58	w.	Do.....	12	65	e.
Nantucket, Mass.....	19	52	ne.	Do.....	13	51	nw.
New York, N. Y.....	2	52	nw.	Do.....	15	51	e.
Do.....	13	63	sw.	Toledo, Ohio.....	13	55	w.
Do.....	15	65	se.	Williston, N. Dak..	2	50	nw.
Do.....	16	54	nw.				

CONDENSED CLIMATOLOGICAL SUMMARY.

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data, as indicated by the several headings.

The mean temperature for each section, the highest

and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course the number of such records is smaller than the total number of stations.

Summary of temperature and precipitation by sections, November, 1914.

Section.	Temperature—in degrees Fahrenheit.						Precipitation—in inches and hundredths.					
	Section average.	Departure from the normal.	Monthly extremes.				Section average.	Departure from the normal.	Greatest monthly.		Least monthly.	
			Station.	Highest.	Date.	Station.	Lowest.	Date.	Station.	Amount.	Station.	Amount.
Alabama.....	53.0	-1.1	3 stations.....	86	4†	Florence.....	9	20	Mobile.....	10.23	Bridgeport.....	1.61
Arizona.....	55.3	+3.2	Sacaton.....	95	5	Chin Lee.....	5	23	Casa Grande.....	2.35	2 stations.....	0.00
Arkansas.....	52.6	+1.7	2 stations.....	88	5†	4 stations.....	11	20	Arkansas City.....	5.62	Eureka Springs.....	0.44
California.....	54.2	+1.3	Santa Barbara.....	98	8	Tamarack.....	-2	30	Weitchpec.....	7.64	28 stations.....	0.00
Colorado.....	38.9	+3.7	Hoehne.....	89	6	Dillon.....	-7	16	Silver Lake.....	0.56	26 stations.....	0.00
Florida.....	64.0	-0.7	Brooksville (1).....	90	6	Fenholloway.....	19	21	Pensacola.....	13.53	Kissimmee.....	0.60
Georgia.....	53.6	-1.2	Poulan.....	90	5	3 stations.....	12	20	Glennville.....	9.73	Quitman.....	1.77
Hawaii (October).....	73.4		Waranae, Oahu.....	93	2	Volcano House, Hawaii.....	47	28†	Kenae Valley, Maui.....	24.18	2 stations.....	0.00
Idaho.....	37.5	+1.4	Rupert.....	82	4†	Pierson.....	-15	30	Prichard.....	5.61	4 stations.....	0.00
Illinois.....	44.9	+3.4	St. Peter.....	85	7	Dakota.....	1	20	Chester.....	1.90	2 stations.....	T.
Indiana.....	43.7	+1.3	Rome.....	81	7	2 stations.....	3	20†	Salamonia.....	2.86	Collegeville.....	T.
Iowa.....	41.0	+6.0	3 stations.....	80	2†	7 stations.....	-4	19	Waverly.....	0.95	Lake Park.....	0.00
Kansas.....	48.3	+5.2	Manhattan.....	88	3	2 stations.....	4	19	Chanute.....	1.86	17 stations.....	0.00
Kentucky.....	46.9	+0.9	Earlington.....	83	2	4 stations.....	5	20	Weeksbury.....	2.52	Irvington.....	0.68
Louisiana.....	58.2	-0.6	Robeline.....	92	6	Antioch.....	17	20	Lakeville.....	10.70	Lafayette.....	2.23
Maryland and Delaware.....	44.5	-0.3	Cambridge, Md.....	82	4	Deer Park, Md.....	0	24	Emmitsburg, Md.....	3.43	Chewsville, Md.....	1.04
Michigan.....	36.5	+1.0	Five Channels.....	76	1	2 stations.....	-12	19†	Whitefish Point.....	5.07	Sandusky.....	0.27
Minnesota.....	33.0	+4.0	Fairmont.....	76	2	Roseau.....	-16	17	Winton.....	1.90	5 stations.....	0.00
Mississippi.....	54.6	-0.4	2 stations.....	8	4†	Corinth.....	11	20	Woodville.....	6.20	Holly Bluff.....	1.93
Missouri.....	48.6	+4.0	Crocker.....	89	7	4 stations.....	2	19†	Oakfield.....	2.07	4 stations.....	T.
Montana.....	37.7	+5.8	Bridger.....	84	2	Bowen.....	-19	16	Belton.....	5.72	4 stations.....	0.00
Nebraska.....	42.6	+6.3	North Loup.....	87	6	3 stations.....	-7	19	Wahoo.....	0.15	43 stations.....	0.00
Nevada.....	41.6	+1.5	2 stations.....	88	2†	Tecoma.....	-11	22	Gold Creek.....	0.29	20 stations.....	0.00
New England.....	36.7	-0.5	Durham, N. H.....	76	1	2 stations (Vt.).....	-10	24	Rockport, Mass.....	4.10	Burlington, Vt.....	1.41
New Jersey.....	43.3	+0.4	3 stations.....	80	4	Sussex.....	6	24	Charlottesville.....	4.81	Atlantic City.....	1.21
New Mexico.....	44.9	+2.3	Fort Sumner.....	85	4	Elizabethtown.....	0	18†	Plainview (near).....	2.34	73 stations.....	0.00
New York.....	36.1	-0.4	Spier Falls.....	77	1	Indian Lake.....	-16	24	Old Forge.....	6.03	Romulus.....	0.22
North Carolina.....	48.5	-1.0	Lumberton.....	83	3	Ramseur.....	0	21	Highlands.....	10.98	Hatteras.....	1.63
North Dakota.....	30.7	+4.9	Cando.....	83	2	Westhope.....	-30	16	Willow City.....	0.83	Orange.....	0.00
Ohio.....	42.1	+1.1	Upper Sandusky.....	80	7	Bellefontaine.....	5	20	Kingsville.....	3.44	Chillicothe.....	0.40
Oklahoma.....	53.2	+3.3	Mutual.....	95	1	4 stations.....	14	19†	Ravia.....	4.30	9 stations.....	0.00
Oregon.....	42.5	0.0	Powell Butte.....	76	11	Cliff.....	-1	21	Astoria.....	11.26	3 stations.....	0.00
Pennsylvania.....	40.6	0.0	Irwin.....	81	4	Wellsboro.....	-2	24	Edinboro.....	4.27	Cheat Haven.....	0.57
Porto Rico.....	76.9	+0.1	Corozal.....	100	11	Maricao.....	50	3†	Inabon Falls.....	23.00	Guanica Centrale.....	1.93
South Carolina.....	52.4	-1.4	2 stations.....	86	5	2 stations.....	17	21	Meriwether.....	5.89	Darlington.....	1.63
South Dakota.....	38.6	+6.1	3 stations.....	77	1†	Eureka.....	-16	19	Timber Lake.....	0.70	18 stations.....	0.00
Tennessee.....	48.1	0.0	Johnsonville.....	88	7	Mountain City.....	-5	20	Franklin (near).....	4.05	New River.....	0.69
Texas.....	57.7	+0.8	San Juanito.....	96	8	2 stations.....	18	17†	Liberty.....	10.91	9 stations.....	0.00
Utah.....	38.9	+1.1	Low.....	85	12†	3 stations.....	-5	20†	Lower Mill Creek.....	0.59	26 stations.....	0.00
Virginia.....	45.7	-0.2	Fredericksburg.....	82	4	Burkes Garden.....	7	24	Waynesboro.....	4.75	Hot Springs.....	0.58
Washington.....	41.8	+1.4	Anatone.....	72	1	Snyders Ranch.....	2	15	Quinalt.....	24.29	Eltopia.....	0.03
West Virginia.....	42.6	-0.2	2 stations.....	84	2†	Bayard.....	2	22	Martinsburg.....	2.27	St. Marys.....	0.50
Wisconsin.....	34.8	+2.5	Prairie du Chien.....	75	2	Weyerhaeuser (2).....	-10	20	Cecil.....	2.78	Prairie du Chien.....	T.
Wyoming.....	36.1	+3.7	Wheatland.....	86	5	2 stations.....	-13	15†	Upper Geyser Basin.....	1.05	9 stations.....	0.00

† Other dates also.

DESCRIPTION OF TABLES AND CHARTS.

Table I gives the data ordinarily needed for climatological studies for about 158 Weather Bureau stations making simultaneous observations at 8 a. m. and 8 p. m., seventy-fifth meridian time daily, and for about 41 others making only one observation. The altitudes of the instruments above ground are also given.

Table II gives a record of precipitation, the intensity of which at some period of the storm's continuance equaled or exceeded the following rates:

Duration (minutes).....	5	10	15	20	25	30	35	40	45	50	60
Rates per hour (inches).....	3.00	1.80	1.40	1.20	1.08	1.00	0.94	0.90	0.87	0.84	0.80

It is impracticable to make this table sufficiently wide to accommodate on one line the record of accumulated falls that continue at an excessive rate for several hours. In this case the record is broken at the end of each 50

minutes, the accumulated amounts being recorded on successive lines until the excessive rate ends.

In cases where no storm of sufficient intensity to entitle it to a place in the full table has occurred, the greatest precipitation of any single storm has been given, also the greatest hourly fall during that storm.

Table III gives, for about 30 stations of the Canadian Meteorological Service, the means of pressure and temperature, total precipitation and depth of snowfall, and the respective departures from normal values, except in the case of snowfall.

Chart I.—Hydrographs for several of the principal rivers of the United States.

Chart II.—Tracks of centers of high areas; and

Chart III.—Tracks of centers of low areas. The roman numerals show the chronological order of the centers. The figures within the circles show the days of the month;

the letters *a* and *p* indicate, respectively, the observations at 8 a. m. and 8 p. m., seventy-fifth meridian time. Within each circle is also given (Chart II) the last three figures of the highest barometric reading and (Chart III) the lowest reading reported at or near the center at that time, and in both cases as reduced to sea level and standard gravity.

Chart IV.—Temperature departures. This chart presents the departures of the monthly mean temperatures from the monthly normals. The normals used in computing the departures were computed for a period of 31 years (1873 to 1903) and are published in Weather Bureau Bulletin "R," Washington, 1908. The shaded portions of the chart indicate areas of positive departures and unshaded portions indicate areas of negative departures. Generalized lines connect places having approximately equal departures of like sign. This chart of monthly temperature departures in the United States was first published in the Monthly Weather Review for July, 1909.

Chart V.—Total precipitation. The scale of shades showing the depth is given on the chart. Where the monthly amounts are too small to justify shading, and over sections of the country where stations are too widely separated or the topography is too diversified to warrant reasonable accuracy in shading, the actual depths are given for a limited number of representative stations. Amounts less than 0.005 inch are indicated by the letter T, and no precipitation by 0.

Chart VI.—Percentage of clear sky between sunrise and sunset. The average cloudiness at each Weather Bureau station is determined by numerous personal observations between sunrise and sunset. The difference between the observed cloudiness and 100 is assumed to represent the percentage of clear sky, and the values thus obtained are

the basis of this chart. The chart does not relate to the night time.

Chart VII.—Isobars and isotherms at sea level and prevailing wind directions. The pressures have been reduced to sea level and standard gravity by the method described by Prof. Frank H. Bigelow on pages 13-16 of the REVIEW for January, 1902. The pressures have also been reduced to the mean of the 24 hours by the application of a suitable correction to the mean of the 8 a. m. and 8 p. m. readings at stations taking two observations daily, and to the 8 a. m. or the 8 p. m. observations, respectively, at stations taking but a single observation. The diurnal corrections so applied will be found in the Annual Report of the Chief of the Weather Bureau, 1900-1901, volume 2, Table 27, pages 140-164.

The isotherms on the sea-level plane have been constructed by means of the data summarized in chapter 8 of volume 2 of the annual report just mentioned. The correction $t_0 - t$, or temperature on the sea-level plane minus the station temperature as given by Table 48 of that report, is added to the observed surface temperature to obtain the adopted sea-level temperature.

The prevailing wind directions are determined from hourly observations at the great majority of the stations; a few stations having no self-recording wind direction apparatus determine the prevailing direction from the daily or twice-daily observations only.

Chart VIII.—Total snowfall. This is based on the reports from regular and cooperative observers and shows the depth in inches and tenths of the snowfall during the month. In general, the depth is shown by lines inclosing areas of equal snowfall, but in special cases figures are also given.

Chart VIII is published only when the general snow cover is sufficiently extensive to justify its preparation.

TABLE I.—Climatological data for United States Weather Bureau stations, November, 1914.

Districts and stations.	Elevation of instruments.			Pressure in inches.		Temperature of the air, in degrees Fahrenheit.										Precipitation, inches.		Wind.							Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow on ground at end of month.	
	Barometer above sea level, feet.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max. + min. +2.	Departure from normal.	Maximum.	Date.	Mean minimum.	Date.	Mean minimum.	Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity, per cent.	Total.	Departure from normal.	Days with 0.01 or more.	Total movement, miles.	Prevailing direction.	Miles per hour.	Direction.						Date.	Clear days.
New England.																														
Eastport.	76	67	85	29.90	29.98	-.03	35.6	-1.2	58	1 44	12	18	28	33	32	28	75	2.78	-1.3	10	8,704	sw.	55	ne.	20	5	11	14	6.8	4.5
Greenville.	1,070	8		28.78	29.98		28.4		59	1 37	2	19	20	33	32	28	75	2.10		9		se.								9.7
Portland, Me.	103	82	117	29.91	30.03	-.01	36.6	-1.0	72	1 45	14	23	28	34	32	25	66	3.17	-0.6	9	7,728	sw.	48	se.	16	12	4	14	5.5	7.4
Concord.	288	70	79	29.73	30.01	-.01	35.0	-1.8	73	1 45	11	23	25	44				2.27	-1.1	8	4,271	nw.	30	w.	17	12	6	12	5.3	8.8
Burlington.	404	11	48	29.56	30.01	-.04	33.1	+0.2	65	1 42	7	24	26	31				1.41	-1.2	13	10,125	s.	46	s.	24	3	9	18	7.5	14.9
Northfield.	876	12	60	29.06	30.03	-.02	31.5	+0.5	69	1 41	6	24	22	43	28	25	70	2.90	+0.3	12	6,228	s.	37	sw.	4	4	7	19	7.4	T.
Boston.	125	115	188	29.90	30.04	-.01	42.7	+1.5	74	1 51	20	24	35	28	38	32	69	2.72	-1.4	6	8,494	w.	43	ne.	19	7	11	12	5.8	T.
Nantucket.	12	14	90	30.04	30.05	-.00	44.4	+0.8	63	1 51	22	24	38	24	41	36	74	2.32	-1.0	8	12,833	w.	52	ne.	19	8	14	8	5.5	T.
Block Island.	26	11	46	30.02	30.05	-.01	44.2	+1.1	62	2 50	24	23	39	18	41	35	71	2.72	-1.2	5	16,010	sw.	58	ne.	19	8	6	16	6.4	T.
Narragansett Pier.	9						42.2	+0.1	64	2 51	16	24	34	28				2.59		7		sw.				17	5			T.
Providence.	160	215	251	29.88	30.06	-.01	40.8	+0.4	70	1 49	18	24	33	29	36	30	66	1.96	-1.9	8	10,269	nw.	50	nw.	2	11	12	7	5.0	T.
Hartford.	159	122	140	29.89	30.07	-.01	41.0	+1.5	72	1 49	20	23	33	29	35	29	66	2.38	-1.4	7	6,273	sw.	46	sw.	13	8	12	10	5.8	4.5
New Haven.	106	117	155	29.95	30.07	-.00	42.6	+1.3	71	4 51	19	24	34	27	36	30	65	3.28	-0.3	7	7,572	n.	40	n.	19	12	8	10	4.8	1.4
Middle Atlantic States.																														
Albany.	97	102	115	29.95	30.06	-.02	38.1	-0.3	71	4 46	13	24	30	30	33	28	70	2.19	-0.6	10	5,627	s.	42	s.	13	7	9	14	6.5	7.9
Binghamton.	871	10	69	29.11	30.06	-.03	38.2	+0.6	66	4 46	8	24	30	29				1.10	-1.2	14	4,377	nw.	28	nw.	13	5	13	12	6.6	4.7
New York.	314	414	454	29.74	30.08	-.01	44.0	+0.0	73	4 52	22	23	36	25	38	30	62	2.08	-1.4	6	15,325	sw.	65	se.	15	11	9	10	5.5	T.
Harrisburg.	374	94	104	29.72	30.14	+.03	43.2	+1.5	74	4 52	21	24	35	29	36	29	62	1.25	-1.1	4	5,650	w.	34	sw.	13	7	17	6	5.2	T.
Philadelphia.	117	123	190	29.99	30.12	+.02	46.2	+1.3	76	4 54	26	21	38	29	40	33	65	1.79	-1.3	6	8,339	sw.	36	sw.	13	18	6	6	3.9	T.
Reading.	325	81	98	29.76	30.12	+.03	43.8	+1.1	74	4 52	23	24	35	30	37	29	62	2.14	-1.0	3	5,742	nw.	33	e.	15	10	11	9	5.7	T.
Scranton.	805	111	119	29.21	30.10	+.01	40.2	+1.1	69	4 48	15	24	32	30	35	30	71	1.12	-1.2	7	5,170	s.	35	sw.	13	3	17	10	6.1	3.6
Atlantic City.	52	37	48	30.06	30.12	+.02	46.0	+0.5	70	2 53	22	24	39	26	41	35	68	1.21	-2.0	6	6,356	nw.	34	s.	15	13	10	7	4.5	T.
Cape May.	18	13	49	30.12	30.14	+.04	47.3	+0.1	74	4 54	24	24	40	25				1.76	-1.5	7	7,311	sw.	40	se.	15	14	13	3	4.2	T.
Trenton.	190	159	183	29.89	30.10	+.03	43.5	+0.2	76	4 52	22	24	35	31	37	31	67	1.62	-1.8	6	9,506	sw.	46	sw.	13	13	10	7	4.8	T.
Baltimore.	123	100	113	30.00	30.14	+.03	47.0	+1.2	79	4 56	26	21	38	31	40	32	61	2.18	-0.7	3	5,367	sw.	37	n.	8	16	7	7	4.1	T.
Washington.	112	62	85	30.00	30.13	+.01	45.4	+0.4	79	4 56	20	24	35	32	39	32	66	2.06	-0.6	4	5,186	nw.	38	nw.	16	15	5	10	4.4	T.
Lynchburg.	681	153	188	29.39	30.14	+.01	46.6	+0.5	79	4 58	16	24	35	38	39	31	61	2.31	-0.5	6	5,692	w.	30	nw.	20	14	10	6	5.1	T.
Mount Weather.	1,725	10	75	28.24	30.11	+.01	41.4	+1.0	74	4 50	16	21	33	34	35	27	59	2.39	-0.5	4	14,503	w.	74	nw.	16	11	12	7	5.4	T.
Norfolk.	91	170	205	30.05	30.15	+.04	51.0	+0.2	77	4 59	25	21	43	37	44	38	67	2.62	-0.1	3	9,734	sw.	38	se.	15	17	3	10	4.2	T.
Richmond.	144	11	52	29.99	30.15	+.03	48.0	+0.8	80	4 59	21	24	37	37	40	33	63	2.20	-0.2	6	5,936	sw.	40	sw.	8	17	6	7	3.5	T.
Wichville.	2,293	40	47	27.75	30.19	+.06	41.8	-1.2	70	4 52	12	21	32	37	35	30	73	2.51	-0.5	6	4,372	w.	24	nw.	16	21	4	5	2.7	1.5
South Atlantic States.																														
Asheville.	2,255	70	84	27.79	30.20	+.06	44.1	-1.0	72	7 56	9	20	32	35	37	32	70	4.06	+0.8	8	5,323	nw.	40	e.	14	18	4	8	4.0	1.3
Charlotte.	773	68	76	29.31	30.16	+.03	50.5	+0.1	77	4 60	19	21	41	33	42	35	63	2.45	-0.4	6	4,651	sw.	27	ne.	29	15	6	9	4.5	T.
Hatteras.	11	12	50	30.12	30.13	+.02	55.6	-0.1	75	8 62	32	21	49	22	51	47	76	1.63	-3.0	6	10,237	n.	56	se.	15	13	7	10	4.7	T.
Manteo.	12	4	46				51.0		79	4 63	27	22	39	33				2.66	-2.0	6		sw.				20	3	7		
Raleigh.	376	103	110	29.74	30.16	+.03	50.8	+0.6	78	4 61	17	21	41	33	42	34	60	3.38	+1.0	5	5,600	ne.	25	ne.	9	18	4	8	3.7	3.6
Wilmington.	78	81	91	30.07	30.16	+.04	54.4	+0.3	79	3 64	24	21	44	31	47	41	70	3.30	+0.8	5	5,044	w.	29	e.	14	18	6	6	3.4	T.
Charleston.	48	11	92	30.09	30.14	+.02	57.0	+1.1	79	5 65	27	21	49	26	50	45	70	2.34	-0.5	6	7,730	n.	38	ne.	28	19	5	6	3.4	T.
Columbia, S. C.	351	41	57	29.77	30.16	+.04	53.3	+0.5	81	5 65	22	21	42	36	44	36	60	3.48	+1.2	6	4,508	ne.	25	w.	20	20	2	8	3.4	T.
Augusta.	180	89	97	29.96	30.16	+.03	53.4	+0.5	81	5 66	21	20	41	36	46	42	76	4.92	+2.0	7	3,941	nw.	37	w.	19	17	4	9	4.6	T.
Savannah.	65	150	194	30.07	30.14	+.02	58.0	+0.5	80	3 67	24	20	49	26	50	45	70	5.55	+3.2	8	9,023	ne.	48	nw.	20	15	6	9	4.3	T.
Jacksonville.	43	96	129	30.07	30.12	+.02	61.1	-0.2	83	5 70	29	21	53	26	54	51	76	3.87	+1.7	7	6,584	ne.	30	w.	20	14	6	10	4.6	T.
Florida Peninsula.																														
Key West.	22	10	64	30.00	30.02	-.00	73.0	-1.3	85	15 77	55	21	69	15	67	65	79	2.33	0.0	10	8,477	ne.	34	n.	20	8	9	13	6.2	T.
Miami.	25	71	79	30.01	30.04	-.03	70.6	-1.4	82	9 75	36	21	66	25	65	61	73	7.06	+4.5	10	8,563	ne.	31	ne.	24	6	8	16	7.1	T.
Sand Key.	23	39	72	29.96	29.99	-.03	73.3		83	15 76	55	21	71	10	68	65	76	3.20	+0.3	10	14,539	ne.	42	nw.	20	8	9	13	6.2	T.
Tampa.	35	79	96	30.04	30.08	-.00	66.2	+0.8	82	8 75	32	21	58	28	59	55	75	2.05	+0.3	7	5,512	ne.	30	nw.	20	6	13	11	6.1	T.
Titusville.	44	6		30.03	30.08		66.4	+0.5	84	15 74	30	21	59	29				1.05		10		nw.				9	13	8	5.3	T.
East Gulf States.																														
Atlanta.	1,174	190	216	28.90	30.16	+.03	52.4	-0.5	75	5 61	14	20	44	31	44	35	59													

TABLE I.—Climatological data for United States Weather Bureau stations, November, 1914—Continued.

Districts and stations.	Elevation of instruments.			Pressure in inches.			Temperature of the air, in degrees Fahrenheit.										Precipitation, inches.			Wind.					Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow on ground at end of month.		
	Barometer above sea level, feet.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max. + min. + 2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity, per cent.	Total.	Departure from normal.	Days with 0.01 or more.	Total movement, miles.	Prevailing direction.	Maximum velocity.								
																								Miles per hour.							Direction.	Date.
Ohio Valley and Tennessee.																																
Chattanooga.....	762	189	213	29.36	30.19	+ .05	50.1	- 0.2	79	4	61	12	20	39	35	42	34	62	3.21	- 0.4	8	4,860	n.	37	nw.	19	13	9	8	4.3	0.5	
Knoxville.....	996	93	100	29.10	30.18	+ .05	47.8	+ 0.7	76	4	56	13	20	36	35	41	36	71	1.29	- 2.3	2	3,350	no.	27	nw.	19	13	8	9	4.6	0.9	
Memphis.....	399	76	97	29.75	30.19	+ .07	53.6	+ 2.2	80	6	61	16	23	45	27	46	39	62	2.05	- 1.5	6	5,115	s.	47	nw.	15	18	2	10	4.1	T.	
Nashville.....	546	168	191	29.59	30.19	+ .07	49.6	+ 0.9	79	6	61	10	20	38	39	42	34	60	2.13	- 1.7	6	5,311	sw.	42	nw.	15	16	5	9	4.2	T.	
Lexington.....	989	75	102	29.07	30.16	+ .04	45.7	+ 1.0	75	7	58	8	20	36	30	33	30	58	1.62	- 1.9	6	7,817	sw.	38	nw.	15	16	6	8	4.2	T.	
Louisville.....	525	219	255	29.58	30.16	+ .04	48.5	+ 2.2	77	7	58	10	20	39	30	41	35	65	0.75	- 3.4	4	8,723	s.	38	nw.	15	17	4	9	4.5	T.	
Evansville.....	431	72	82	29.68	30.16	+ .04	49.2	+ 3.9	78	7	57	12	21	40	31	41	34	63	0.65	- 3.5	4	5,051	s.	27	sw.	12	17	7	6	4.1	T.	
Indianapolis.....	522	154	164	29.22	30.13	+ .03	44.2	+ 2.7	74	7	58	8	20	35	31	37	30	64	1.45	- 2.1	6	5,723	sw.	31	sw.	10	16	5	9	4.9	T.	
Terre Haute.....	575	96	129	29.49	30.12	+ .04	46.0	+ 2.1	77	7	56	10	20	36	35	39	32	66	1.39	- 2.0	4	7,094	sw.	34	nw.	15	6	18	6	5.4	T.	
Cincinnati.....	628	152	160	29.45	30.14	+ .02	46.7	+ 2.1	77	7	57	11	20	37	34	39	31	59	1.29	- 2.0	4	5,305	sw.	26	w.	15	16	8	6	4.2	T.	
Columbus.....	824	173	222	29.23	30.13	+ .02	42.9	+ 1.5	74	7	52	11	20	33	30	37	32	70	1.99	- 1.1	10	9,542	sw.	42	nw.	15	12	7	11	4.6	T.	
Dayton.....	896	181	216	29.13	30.11	+ .02	41.8	+ 1.7	76	7	53	11	20	34	29	37	31	67	1.11	- 1.8	8	8,217	sw.	34	nw.	15	17	7	6	3.6	T.	
Pittsburgh.....	842	353	410	29.29	30.12	+ .02	42.9	+ 0.9	72	7	51	18	21	34	34	37	30	64	1.35	- 1.2	7	9,738	sw.	47	sw.	13	5	13	12	6.2	4.0	
Elkins.....	1,940	41	50	28.06	30.18	+ .06	41.4	+ 1.8	71	3	53	8	24	30	45	24	27	64	0.73	- 2.1	7	3,968	w.	21	sw.	29	12	7	11	5.2	4.0	
Parkersburg.....	638	77	84	29.49	30.16	+ .04	45.4	+ 2.2	76	7	56	16	20	35	38	38	32	66	0.89	- 2.0	6	4,502	sw.	32	nw.	16	15	7	8	4.3	0.8	
Lower Lake Region.																																
Buffalo.....	767	247	280	29.18	30.03	- .02	40.0	+ 0.7	64	7	46	19	18	33	26	36	33	80	1.81	- 1.5	13	16,425	nw.	84	sw.	13	2	11	17	7.6	2.6	
Canton.....	448	10	61	29.51	30.00	- .03	34.6	+ 0.7	64	1	43	4	23	26	35	35	30	73	2.31	- 1.1	13	9,701	sw.	60	w.	4	8	6	16	6.9	10.3	
Oswego.....	335	76	91	29.64	30.02	- .03	38.5	- 0.6	67	1	46	14	18	31	28	35	30	73	3.05	- 0.4	16	10,012	nw.	43	nw.	13	2	8	20	7.7	13.6	
Rochester.....	523	97	113	29.46	30.05	- .03	33.6	+ 1.7	68	1	47	17	21	32	28	34	29	69	1.40	- 1.4	14	8,445	w.	44	w.	13	4	7	19	7.3	4.7	
Syracuse.....	597	97	113	29.39	30.05	- .01	38.6	- 0.1	66	1	46	15	18	31	29	34	28	70	1.05	- 1.6	15	10,555	sw.	50	w.	13	3	9	18	7.3	6.3	
Erie.....	714	92	102	29.26	30.05	- .01	41.7	+ 0.6	72	4	49	19	20	35	36	36	30	65	2.21	- 1.4	15	11,362	s.	43	sw.	15	2	9	19	7.6	10.5	
Cleveland.....	762	190	201	29.24	30.08	+ .01	41.8	+ 0.4	75	5	50	18	20	34	38	36	30	65	1.34	- 1.4	8	12,617	sw.	50	w.	13	3	8	19	7.5	0.7	
Sandusky.....	629	62	103	29.33	30.08	+ .03	41.6	+ 0.8	74	7	50	14	20	33	31	37	32	72	0.98	- 1.8	8	11,295	sw.	48	w.	13	9	7	14	6.1	0.6	
Toledo.....	628	208	246	29.33	30.09	+ .02	41.6	+ 0.9	71	5	50	16	20	33	32	37	32	74	0.68	- 2.0	8	12,913	sw.	55	w.	13	12	7	11	5.2	0.6	
Fort Wayne.....	856	113	124	29.15	30.10	+ .02	41.4	+ 0.8	70	7	51	11	19	32	27	36	31	72	0.75	- 1.8	6	8,344	sw.	38	sw.	13	12	6	12	5.4	0.4	
Detroit.....	730	218	245	29.25	30.09	- .03	39.6	+ 1.0	68	7	47	16	20	32	27	35	30	74	1.65	- 1.0	11	11,193	w.	48	w.	13	6	9	15	6.8	0.7	
Upper Lake Region.																																
Alpena.....	609	13	92	29.30	29.98	- .03	34.6	+ 0.9	67	1	42	9	19	28	25	32	28	81	2.10	- 0.5	16	10,402	w.	52	sw.	3	3	14	13	6.8	9.2	
Escanaba.....	612	54	60	29.30	29.98	- .03	34.0	+ 0.3	66	26	41	6	18	27	33	30	25	73	1.85	- 0.4	12	7,848	nw.	31	sw.	13	6	7	17	6.7	2.8	
Grand Haven.....	632	54	92	29.33	30.03	- .01	40.0	+ 0.2	61	3	46	17	18	34	22	36	32	73	1.94	- 0.6	11	11,624	w.	53	w.	17	10	5	15	5.9	11.0	
Grand Rapids.....	707	70	87	29.26	30.04	- .01	34.6	+ 1.5	64	3	46	18	20	33	22	35	31	75	1.47	- 1.1	11	5,823	w.	28	w.	11	3	9	18	7.4	9.2	
Houghton.....	684	62	72	29.20	29.94	- .08	32.4	+ 0.9	61	1	39	3	18	26	28	30	26	70	2.60	- 0.2	16	8,515	nw.	43	nw.	17	1	7	22	8.4	11.0	
Lansing.....	878	11	62	29.08	30.04	- .03	37.6	+ 0.8	65	3	47	11	19	28	27	33	29	80	1.40	- 1.0	13	5,986	sw.	30	nw.	4	11	5	14	5.7	3.5	
Ludington.....	637	60	66	29.30	30.00	- .03	38.0	+ 0.8	68	3	44	18	19	32	23	37	34	85	1.28	- 0.4	12	10,500	nw.	44	sw.	18	5	8	17	7.1	3.6	
Marquette.....	734	77	111	29.17	29.99	- .03	33.7	+ 1.8	64	26	40	1	18	27	34	30	25	73	2.43	- 0.4	18	9,285	w.	42	w.	4	1	4	25	8.8	13.4	
Port Huron.....	638	70	120	29.32	30.03	- .02	37.7	+ 0.9	67	7	46	9	20	29	32	34	30	77	1.18	- 1.5	9	9,936	w.	44	w.	13	5	11	14	6.7	0.3	
Saginaw.....	641	48	82	29.32	30.03	- .03	37.4	+ 0.8	64	26	45	11	19	29	26	34	31	83	1.53	- 0.8	10	8,666	w.	36	w.	4	8	8	14	6.6	1.4	
Sault Ste. Marie.....	614	11	61	29.25	29.96	- .05	31.5	+ 0.8	63	1	37	8	20	26	25	29	27	84	4.08	+ 1.2	20	8,800	nw.	46	nw.	17	1	5	24	8.8	20.3	
Chicago.....	823	140	310	29.17	30.07	- .03	44.4	+ 5.2	71	1	51	12	20	37	28	38	31	62	0.33	- 2.2	6	10,006	w.	34	s.	2	17	3	10	4.2	T.	
Green Bay.....	617	103	144	29.33	30.01	- .03	35.8	+ 3.3	65	1	43	10	19	28	27	31	26	72	1.78	- 0.2	8	9,506	w.	37	w.	4	7	13	10	6.4	3.3	
Milwaukee.....	681	119	133	29.29	30.04	- .01	40.4	+ 4.3	68	1	48	8	19	33	29	35	29	68	0.47	- 1.5	6	8,576	w.	35	e.	12	9	11	10	5.5	0.2	
Duluth.....	1,133	11	47	28.76	30.01	- .03	29.8	+ 0.5	54	3	37	4	19	23	23	27	23	80	1.15	- 0.4	7	10,425	w.	46	w.	21	8	13	9	5.5	4.6	
North Dakota.																																
Moorhead.....	940	8	57	29.01	30.06	- .01	31.1	+ 6.7	64	2	41	6	17	21	40	27	24	80	0.36	- 0.6	2	7,333	nw.	32	w.	3	15	8	7	4.0	3.2	
Bismarck.....	1,674	8	57	28.26	30.09	+ .02	34.6	+ 8.6	67	1	46	9	19	23	39	28	23	72	0.42	- 0.3	1	7,845	nw.	46	nw.	3	13	11	6	4.5	3.2	
Devils Lake.....	1,482	11	44	28.38	30.01	- .05	23.0	+ 6.4	63																							

TABLE I.—Climatological data for United States Weather Bureau stations, November, 1914—Continued.

Districts and stations.	Elevation of instruments.			Pressure in inches.			Temperature of the air, in degrees Fahrenheit.										Precipitation, inches.			Wind.					Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow on ground at end of month.																									
	Barometer above sea level, feet.	Thermometer above ground.	Altimeter above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max. + min. +2.	Departure from normal.	Maximum.	Date.	Mean minimum.	Date.	Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity, per cent.	Total.	Departure from normal.	Days with 0.01 or more.	Total movement, miles.	Prevailing direction.	Miles per hour.	Direction.	Date.																															
Northern Slope.																														39.1 + 7.0										61			0.21 - 0.5												
Havre.....	2,505	11	44	27.33	30.01	-.02	36.7 + 6.1	68	25	48	-1	16	26	35	32	27	74	0.24	-0.5	3	7,035	sw.	38	sw.	2	5	9	16	6.9	2.3																									
Helena.....	4,110	87	114	25.83	30.09	-.01	39.0 + 6.3	62	1	48	5	16	30	27	32	25	61	0.27	-0.4	3	5,645	sw.	43	w.	13	3	13	14	6.6	T.																									
Kalispell.....	2,962	11	34	26.98	30.09	-.02	36.4 + 3.2	55	9	43	13	16	30	27	33	30	80	1.58	-0.3	13	2,482	nw.	27	sw.	5	4	7	19	7.8	3.6	T.																								
Miles City.....	2,371	26	48	27.51	30.11	-.04	40.8 + 9.9	70	25	53	7	16	28	45	33	28	68	0.18	-0.4	5	3,305	s.	30	w.	9	19	8	3	3.3	1.1																									
Rapid City.....	3,259	50	58	26.63	30.11	-.03	42.8 + 9.2	70	5	56	6	16	29	42	34	23	50	0.04	-0.4	1	5,930	w.	48	n.	13	7	16	7	5.7	0.5																									
Cheyenne.....	6,088	84	101	24.06	30.12	-.05	41.4 + 6.5	70	5	54	1	16	28	38	30	18	48	0.26	-0.2	2	9,203	w.	46	w.	14	18	11	1	3.7	2.7	1.4																								
Lander.....	5,372	60	68	24.71	30.17	-.07	37.5 + 8.8	71	1	55	3	16	20	55	27	16	49	0.00	-0.6	0	3,108	sw.	74	sw.	13	13	15	2	4.2	1.0																									
Sheridan.....	3,790	10	47	26.14	30.14	-.07	36.6 + 8.8	69	25	54	-10	16	19	52	28	20	62	0.08	-1.1	3	3,080	s.	48	nw.	13	5	14	11	6.2	1.0																									
Yellowstone Park.....	6,200	11	48	23.95	30.18	-.07	33.8 + 4.5	57	5	44	0	16	23	35	27	19	56	0.35	-1.1	5	6,644	s.	43	s.	13	8	12	10	6.1	2.8	0.4																								
North Platte.....	2,821	11	51	27.16	30.15	-.07	43.7 + 8.6	80	6	61	13	16	27	48	32	23	59	T.	-0.4	0	4,459	n.	27	n.	12	17	11	2	3.0	T.																									
Middle Slope.																														48.4 + 6.6										58			0.18 0.8												
Denver.....	5,291	129	172	24.80	30.11	+.05	46.2 + 7.0	75	5	61	15	16	31	41	33	19	40	0.30	-0.2	3	5,701	sw.	28	nw.	17	21	9	0	2.2	2.9																									
Pueblo.....	4,685	80	86	25.37	30.14	+.09	43.5 + 4.2	79	5	62	16	19	25	51	31	20	48	T.	-0.4	0	3,563	nw.	25	nw.	20	24	6	0	1.5	T.																									
Concordia.....	1,398	42	50	28.62	30.12	+.04	47.5 + 7.6	83	6	62	7	19	33	42	39	32	64	T.	-0.9	0	4,156	sw.	22	w.	18	13	12	5	4.1	T.																									
Dodge.....	2,509	11	51	27.48	30.12	+.05	48.4 + 7.9	79	2	64	20	19	33	47	38	30	61	T.	-0.6	0	6,194	s.	30	n.	14	21	7	2	2.4	T.																									
Wichita.....	1,358	139	158	28.64	30.09	+.01	50.9 + 7.1	78	3	62	15	19	39	47	43	35	63	0.11	-1.1	2	8,782	s.	38	sw.	14	21	7	2	2.5	3.3																									
Oklahoma.....	1,214	10	47	28.83	30.13	+.05	53.6 + 5.7	82	5	65	23	20	42	37	45	40	69	0.70	-1.6	2	8,232	s.	46	nw.	7	15	13	2	3.3	4.0																									
Southern Slope.																														54.0 + 3.0										70			1.88 + 0.7												
Abilene.....	1,738	10	52	28.29	30.12	+.05	55.4 + 2.8	78	5	66	29	17	45	39	49	45	78	3.48	+2.2	10	4,865	s.	26	ne.	15	11	6	13	5.2	.....																								
Amarillo.....	3,676	10	49	26.35	30.11	+.06	50.4 + 6.6	76	14	64	23	17	37	40	41	35	68	T.	-1.2	0	6,069	sw.	28	s.	17	26	4	0	2.4	.....																								
Del Rio.....	944	64	71	29.08	30.08	+.03	59.8 + 0.5	77	5	67	38	20	52	30	.....	.....	3.76	+2.6	9	4,700	se.	28	nw.	15	10	9	11	5.7	.....																									
Roswell.....	3,566	75	85	26.45	30.10	+.07	50.2 + 2.1	77	7	64	23	19	36	44	42	34	63	0.30	-0.9	4	3,783	n.	21	n.	27	21	5	4	2.7	.....																								
Southern Plateau.																														52.7 + 3.8										53			0.52 + 0.1												
El Paso.....	3,762	110	133	30.04	.....	+.00	54.7 + 3.8	74	7	66	34	20	44	33	.....	.....	1.13	+0.5	6	5,386	se.	33	n.	11	15	11	4	.....	.....																								
Santa Fe.....	7,013	57	62	23.32	30.12	+.09	43.0 + 4.8	63	4	55	24	19	31	30	31	19	45	T.	-0.8	0	4,262	e.	26	n.	12	24	6	0	1.9	.....																								
Flagstaff.....	6,908	8	57	.....	.....	.....	39.0 + 4.4	62	12	55	14	21	23	44	.....	.....	0.10	.....	2	.....	e.	28	e.	19	19	9	2	.....	1.0	.....																								
Phoenix.....	1,108	76	81	28.82	29.97	-.01	63.9 + 5.2	84	6	76	42	30	51	32	54	45	56	1.00	0.0	2	3,145	e.	26	ne.	19	19	8	3	2.9	.....																								
Yuma.....	141	9	58	29.81	29.96	-.02	66.2 + 4.3	90	4	80	45	30	53	33	53	43	52	0.47	+0.2	1	3,083	ne.	24	n.	18	27	2	1	0.9	.....																								
Independence.....	3,910	11	42	26.05	30.07	+.02	49.2 + 0.0	74	3	66	14	30	32	40	39	32	59	0.00	-0.3	0	3,471	nw.	25	se.	27	17	9	4	3.8	.....																								
Middle Plateau.																														41.0 + 1.4										47			0.07 -0.8												
Reno.....	4,532	74	81	25.57	30.17	+.05	43.4 + 2.4	76	4	60	16	20	27	45	34	24	54	T.	-1.1	0	3,863	w.	44	w.	13	19	10	1	2.5	T.																									
Tonopah.....	6,090	12	20	24.16	30.10	.....	46.6 + 3.8	68	4	55	20	30	38	24	34	17	32	0.00	-0.9	0	4,216	se.	24	nw.	28	22	7	1	1.8	.....																								
Winnemucca.....	4,344	18	56	25.73	30.21	+.07	37.8 + 0.3	71	5	57	5	20	18	52	28	17	33	0.02	-0.7	2	4,438	ne.	33	sw.	13	18	5	7	3.2	0.1	.....																							
Modena.....	5,479	10	43	24.72	30.17	+.09	38.4 + 0.6	72	4	58	6	30	19	51	26	11	40	0.00	-0.6	0	6,050	w.	34	sw.	28	20	8	2	2.2	.....																								
Salt Lake City.....	4,360	147	189	25.76	30.19	+.07	43.4 + 3.0	72	5	54	24	15	33	28	35	27	56	0.37	-1.0	2	3,815	se.	34	nw.	13	19	7	4	2.8	1.4	1.0																								
Durango.....	6,546	10	.....	.....	.....	.....	42.2 + 2.3	68	2	57	17	23	28	35	32	20	46	0.02	-0.5	1	4,059	se.	20	nw.	14	24	6	0	1.8	.....																								
Grand Junction.....	4,602	82	96	25.51	30.14	+.06	42.2 + 2.3	68	2	57	17	23	28	35	32	20	46	0.02	-0.5	1	4,059	se.	20	nw.	14	24	6	0	1.8	.....																								
Northern Plateau.																														41.5 + 2.9										63			0.59 -0.8												
Baker.....	3,471	48	53	26.56	30.21	+.05	38.8 + 3.9	64	5	60	15	15	28	33	32	24	58	0.16	-1.0	6	5,375	se.	31	w.	13	8	16	6	5.0	0.7	T.																								
Boise.....	2,739	78	86	27.32	30.23	+.06	41.8 + 2.2	73	5	53	19	22	30	35	34	24	51	0.11	-0.8	4	2,773	nw.	29	nw.	13	8	7	15	6.3	T.																									
Lewiston.....	757	40	48	29.31	30.13	+.01	43.7 + 2.8	71	1	52	28	22	36	26	.....	.....	1.03	-0.3	10	2,006	w.	25	w.	13	1	13	16	7.4	0.5	.....																								
Pocatello.....	4,477	46	54	25.60	30.21	+.07	39.5 + 3.2	68	5	53	14	16	26	39	31	23	57	0.23	-0.3	2	5,107	se.	27	sw.	28	13	13	4	3.9	1.8	0.5																								
Spokane.....	1,929	101	110	28.03	30.12	+.02	40.8 + 3.5	60	8	47	23	15	34	29	37	34	78	1.03	-1.3	10	4,226	sw.	38	sw.	13	0	10	20	8.0	0.3	.....																							
Walla Walla.....	1,000	57	65	29.05	30.14	+.01	44.6 + 1.7	65	3	52	27	17	38	30	40	35	72	1.00	-1.1	8	3,260	s.	36	w.	13	3	7	20	7.9	0.3	.....																							
North Pacific Coast Region.																														46.7 + 1.6										86			7.44 +0.1												
North Head.....	211	11	56	29.83	30.06	+.01	49.4 + 1.7	61	20	53	38	29	46	13	48	46	88	9.49	+3.2	23	13,181	se.	84	s.	12	4	3	28	8.4	.....																								
Port Crescent.....	259	8	53	29.75	30.03	+.03	43.4 + 1.1	59	8	49	30	15	38	17	45	43	87	8.19	+0.7	24	3,999	s.	22	s.	22	1	2	27	9.0	0.3	.....																							
Seattle.....	125	215	250	29.94	30.07	+.03	47.2 + 2.7	59	24	52	33	18	43	17	45	43	87	5.28	-0.6	19	7,533	s.	64	sw.	13	1	5	24	8.6	T.																									
Tacoma.....	213	113	120	29.84	30.08	+.04	45.8 + 1.7	60	24	52	28	18	40	21	44	42	85	5.45	-3.1	20	4,196	sw.	37	sw.	13	0	9	21	8.6	.....																								
Tatoosh Island.....	109	7	57	29.89	29.99	+.02	47.6 + 1.7	56	4	51	34	12	44	21	44	44	88	17.29	+5.2	27	14,179	e.	65	e.	12	2	5	23	8.5	0.1	.....																							
Portland, Oreg.....	153	68	106	29.94	30.10	+.00	47.0 + 1.4	64	4	52	33	19	42	22	44	42	83	3.70	-2.8	15	4,571	s.	30	sw.																															

TABLE II.—Accumulated amounts of precipitation for each 5 minutes, for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during November, 1914, at all stations furnished with self-registering gages.

Stations.	Date.	Total duration.		Total amount of precipitation.	Excessive rate.		Amount before excessive rate began.	Depths of precipitation (in inches) during periods of time indicated.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
		From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
Abilene, Tex.	12			1.17																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								

TABLE II.—Accumulated amounts of precipitation for each 5 minutes, for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during November, 1914, at all stations furnished with self-registering gages—Continued.

Stations.	Date.	Total duration.		Total amount of precipitation.	Excessive rate.		Amount before excessive rate began.	Depths of precipitation (in inches) during periods of time indicated.													
		From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Meridian, Miss.	27			0.89													.22				
Miami, Fla.	8-9	9.35 p. m.	D. N. a. m.	4.79	9.50 p. m.	11.45 p. m.	.02	.10	.46	.83	1.16	1.47	1.77	2.04	2.23	2.36	2.56	2.96	3.48	3.90	4.59
Milwaukee, Wis.	2			0.19														.14			
Minneapolis, Minn.	29-30			0.15														.09			
Mobile, Ala.	13-14	7.10 a. m.	D. N. a. m.	5.27	10.45 p. m.	12.32 a. m.	3.10	.09	.18	.23	.32	.46	.63	.73	.79	.85	.89	.99	1.32	1.77	1.94
Do.	27-28	6.55 a. m.	D. N. a. m.	3.65	7.39 p. m.	8.54 p. m.	.80	.06	.14	.18	.21	.25	.30	.36	.43	.57	.71	1.00	1.37		
Modena, Utah.	0			0.00														.00			
Montgomery, Ala.	28			1.29														.28			
Moorhead, Minn.	12			0.32														*			
Mount Tamalpais, Cal.	1			1.45														.20			
Mount Weather, Va.	15			2.26														.41			
Nantucket, Mass.	16			0.49														.37			
Nashville, Tenn.	29			1.29														.27			
New Haven, Conn.	16			0.79														.25			
New Orleans, La.	26-27	5.55 a. m.	12.25 p. m.	2.62	10.13 a. m.	10.39 a. m.	1.84	.05	.13	.30	.59	.72	.76								
New York, N. Y.	19			0.94																	
Norfolk, Va.	15			1.42														.16			
Northfield, Vt.	19-20			1.34														.32			
North Head, Wash.	5			1.31														*			
North Platte, Nebr.	15, 18, 19			T.														.28			
Oklahoma, Okla.	7			0.55														T.			
Omaha, Nebr.	30			0.02														.29			
Oswego, N. Y.	22-23			0.80														.01			
Palestine, Tex.	12			2.07														*			
Parkersburg, W. Va.	8			0.18														.59			
Pensacola, Fla.	13	2.30 a. m.	6.20 a. m.	1.36	3.23 a. m.	3.42 a. m.	.33	.11	.21	.38	.57	.37	.40	.47	.52	.64	.79	.11			
Do.	13-14	7.10 a. m.	6.35 a. m.	7.52	2.27 a. m.	4.30 a. m.	3.53	.11	.21	.31	.36	.37	.40	.47	.52	.64	.79				
Peoria, Ill.	15			0.16																	
Philadelphia, Pa.	15			1.37														.11			
Phoenix, Ariz.	10			0.84														.22			
Pierre, S. Dak.	18			T.														.28			
Pittsburgh, Pa.	8			0.40														T.			
Pocatello, Idaho.	28			0.13														.12			
Point Reyes Light, Cal.	30			0.97														.08			
Port Huron, Mich.	3			0.46														.41			
Portland, Me.	19			1.47														.30			
Portland, Oreg.	28			0.63														.44			
Providence, R. I.	19			0.82														.24			
Pueblo, Colo.	16			T.														.23			
Raleigh, N. C.	15			1.62														T.			
Rapid City, S. Dak.	18			0.04														.40			
Reading, Pa.	15			1.94														*			
Red Bluff, Cal.	27			0.26														.29			
Reno, Nev.	1, 28, 29			T.														.25			
Richmond, Va.	15			1.29														T.			
Rochester, N. Y.	13			0.20														.21			
Roseburg, Oreg.	13			0.52														.10			
Roswell, N. Mex.	25			0.16														.20			
Sacramento, Cal.	1			0.26														.05			
Saginaw, Mich.	3			0.41														.15			
St. Joseph, Mo.	15			0.08														.34			
St. Louis, Mo.	7			0.67														.08			
St. Paul, Minn.	29-30			0.38														.24			
Salt Lake City, Utah.	29			0.22														*			
San Antonio, Tex.	23-24	10.45 p. m.	6.05 a. m.	1.02	11.33 p. m.	11.54 p. m.	.26	.12	.27	.40	.50	.54						.20			
San Diego, Cal.	9			0.80														.44			
Sand Key, Fla.	7			1.83														*			
Sandusky, Ohio.	15			0.39														.13			
San Francisco, Cal.	30			0.35														*			
San Jose, Cal.	30			0.81														.36			
San Luis Obispo, Cal.	1			0.12														*			
Santa Fe, N. Mex.	2			T.														T.			
Sault Ste. Marie, Mich.	16-17			0.95														*			
Savannah, Ga.	13	2.17 p. m.	7.30 p. m.	0.51	3.18 p. m.	3.38 p. m.	.05	.08	.18	.31	.40							*			
Scranton, Pa.	8			0.34														.08			
Seattle, Wash.	11			0.52														.21			
Sheridan, Wyo.	15			0.06														*			
Shreveport, La.	27			1.37														.32			
Sioux City, Iowa.	18			0.02														*			
Spokane, Wash.	12-13			0.45														*			
Springfield, Ill.	7			0.17														*			
Springfield, Mo.	8			0.44														.17			
Syracuse, N. Y.	19-20			0.37														.16			
Tacoma, Wash.	2			0.78														*			
Tampa, Fla.	9	7.25 a. m.	8.55 a. m.	0.76	8.03 a. m.	8.31 a. m.	.04	.05	.14	.35	.53	.64	.68					.28			
Tatoosh Island, Wash.	1			1.61														.53			
Taylor, Tex.	12			2.30														.59			
Terre Haute, Ind.	8			0.74														.18			
Thomasville, Ga.	29			0.92														.55			
Toledo, Ohio.	8			0.21														.07			
Tononah, Nev.				T.														*			
Topeka, Kans.	7			0.08														.05			
Valentine, Nebr.	7			0.06														*			
Vicksburg, Miss.	8			0.27														.25			
Walla Walla, Wash.	11			0.54														.22			
Washington, D. C.	15			1.64														.24			
Wichita, Kans.	7			0.10														.09			
Williston, N. Dak.	12			0.14														.09			
Wilmington, N. C.	15			2.30														.69			
Winnemucca, Nev.	28			0.01														.01			
Wytheville, Va.	30			0.81														.20			
Yankton, S. Dak.	18			T.														T.			
Yellowstone Park, Wyo.	12-13			0.28														*			

* Self-register not working.

† Record partly estimated.

‡ No precipitation occurred during month.

TABLE III.—Data furnished by the Canadian Meteorological Service, November, 1914.

Stations.	Pressure in inches.			Temperature.						Precipitation.		
	Station reduced to mean of 24 hours.	Sea level reduced to mean of 24 hours.	Departure from normal.	Mean max. + mean min. +2.	Departure from normal.	Mean maximum.	Mean minimum.	Highest.	Lowest.	Total.	Departure from normal.	Total snowfall.
	Inches.	Inches.	Inches.	*F.	*F.	*F.	*F.	*F.	*F.	Inches.	Inches.	Inches.
St. Johns, N. F.	29.70	29.84	-.10	36.6	+ 0.1	42.3	30.9	59	18	6.90	+1.33	T.
Sydney, C. B. I.	29.90	29.94	-.01	38.0	+ 0.9	45.1	31.0	60	20	3.06	-2.38	7.0
Halifax, N. S.	29.88	29.99	-.02	36.6	- 0.7	47.3	26.0	62	9	3.41	-2.25	0.1
Yarmouth, N. S.	29.94	30.01	-.01	39.7	- 0.2	46.1	33.3	58	15	2.93	-1.63	0.5
Charlottetown, P. E. I.	29.91	29.95	-.01	35.6	+ 0.1	41.6	29.7	55	12	2.77	-1.20	4.1
Chatham, N. B.	29.94	29.96	-.01	30.4	- 0.6	37.9	22.9	57	2	3.01	-0.74	9.2
Father Point, Que.	29.89	29.91	-.05	26.6	- 2.3	32.8	20.5	45	0	2.79	-0.32	17.6
Quebec, Que.	29.62	29.96	-.06	26.8	- 2.2	33.5	20.0	50	- 2	4.80	+1.04	20.9
Montreal, Que.	29.76	29.98	-.05	31.2	- 0.6	37.9	24.5	62	3	4.14	+0.40	20.3
Stonecliffe, Ont.	29.30	29.93	-.08	26.8	- 2.3	35.3	18.2	60	- 4	4.29	+1.71	26.9
Ottawa, Ont.	29.73	30.07	+ .05	30.2	- 1.5	36.9	23.4	65	0	3.32	+0.78	13.2
Kingston, Ont.	29.70	30.02	-.02	35.8	+ 0.8	43.9	27.7	59	10	2.45	-0.79	3.2
Toronto, Ont.	29.60	29.99	-.05	38.1	+ 2.5	45.4	30.8	62	13	2.83	-0.31	3.3
White River, Ont.	28.54	29.89	-.09	20.9	+ 0.4	30.7	11.1	47	-16	1.75	-0.10	3.2
Port Stanley, Ont.	29.37	30.03	-.02	38.0	+ 1.2	46.5	29.5	65	14	2.80	-0.57	1.0
Southampton, Ont.	29.28			36.6	+ 1.6	43.8	29.3	58	15	2.69	-1.01	8.3
Parry Sound, Ont.	29.27	29.98	-.03	31.7	- 0.4	40.7	22.7	60	1	5.90	+1.53	33.5
Port Arthur, Ont.	29.23	29.96	-.04	29.2	+ 5.2	37.3	21.2	51	- 7	1.16	-0.17	1.7
Winnipeg, Man.	29.12	29.98	-.06	26.0	+ 8.0	33.5	18.4	55	-13	0.72	-0.36	6.2
Minneapolis, Man.	28.11	30.00	-.04	23.5	+ 1.2	32.4	14.6	60	-22	1.87	+0.87	18.6
Qu'Appelle, Sask.	27.62	29.92	-.08	26.4	+ 7.6	34.8	17.9	57	-22	1.05	+0.16	9.8
Medicine Hat, Alberta.	27.63	30.04	+ .04	37.2	+ 9.8	46.9	27.6	62	0	0.23	-0.69	2.3
Swift Current, Sask.	27.31	29.92	-.10	32.6	+ 9.4	41.6	23.5	65	- 7	0.92	+0.23	7.9
Calgary, Alberta.	26.31	29.91	-.07	32.0	+ 6.2	41.7	22.2	58	-10	2.72	+1.84	27.2
Banff, Alberta.	25.29	29.98	+ .02	28.7	+ 2.9	35.3	22.1	52	-15	2.59	+0.32	24.6
Edmonton, Alberta.	27.54	29.87	-.10	29.8	+ 6.9	37.5	22.0	54	- 6	0.85	+0.27	7.2
Prince Albert, Sask.	28.31	29.92	-.09	22.0	+ 6.6	26.6	17.5	45	-12	1.10	+0.27	5.4
Battleford, Sask.	28.16	29.94	-.08	27.8	+11.5	36.8	18.8	55	-15	0.74	+0.16	6.0
Kamloops, B. C.	28.76	30.00	+ .04	37.7	+ 4.3	42.9	32.6	56	16	1.01	-0.45	4.8
Victoria, B. C.	29.76	29.86	-.13	45.0	+ 1.8	48.4	41.5	54	33	5.83	-1.14	.....
Barkerville, B. C.	25.52	29.88	-.02	26.6	+ 3.0	32.5	20.7	46	- 2	4.51	+1.22	36.5
Hamilton, Bermuda.	29.97	30.13	+ .08	68.0	- 0.7	73.5	62.5	77	59	1.04	-3.34	.....

Chart I. Hydrographs of Several Principal Rivers, November, 1914.

XLII-76.

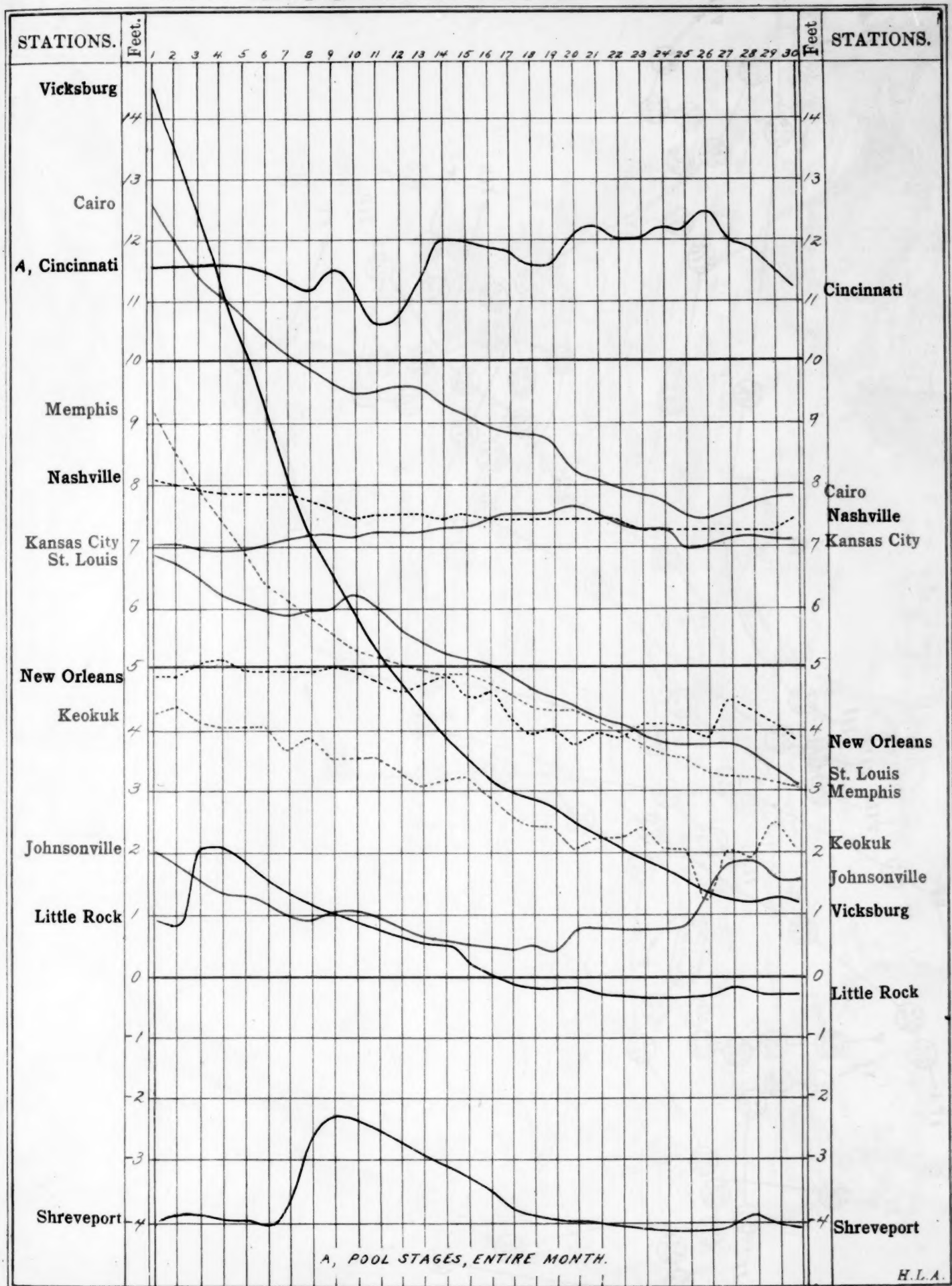


Chart II. Tracks of Centers of High Areas, November, 1914.

XLII-77.

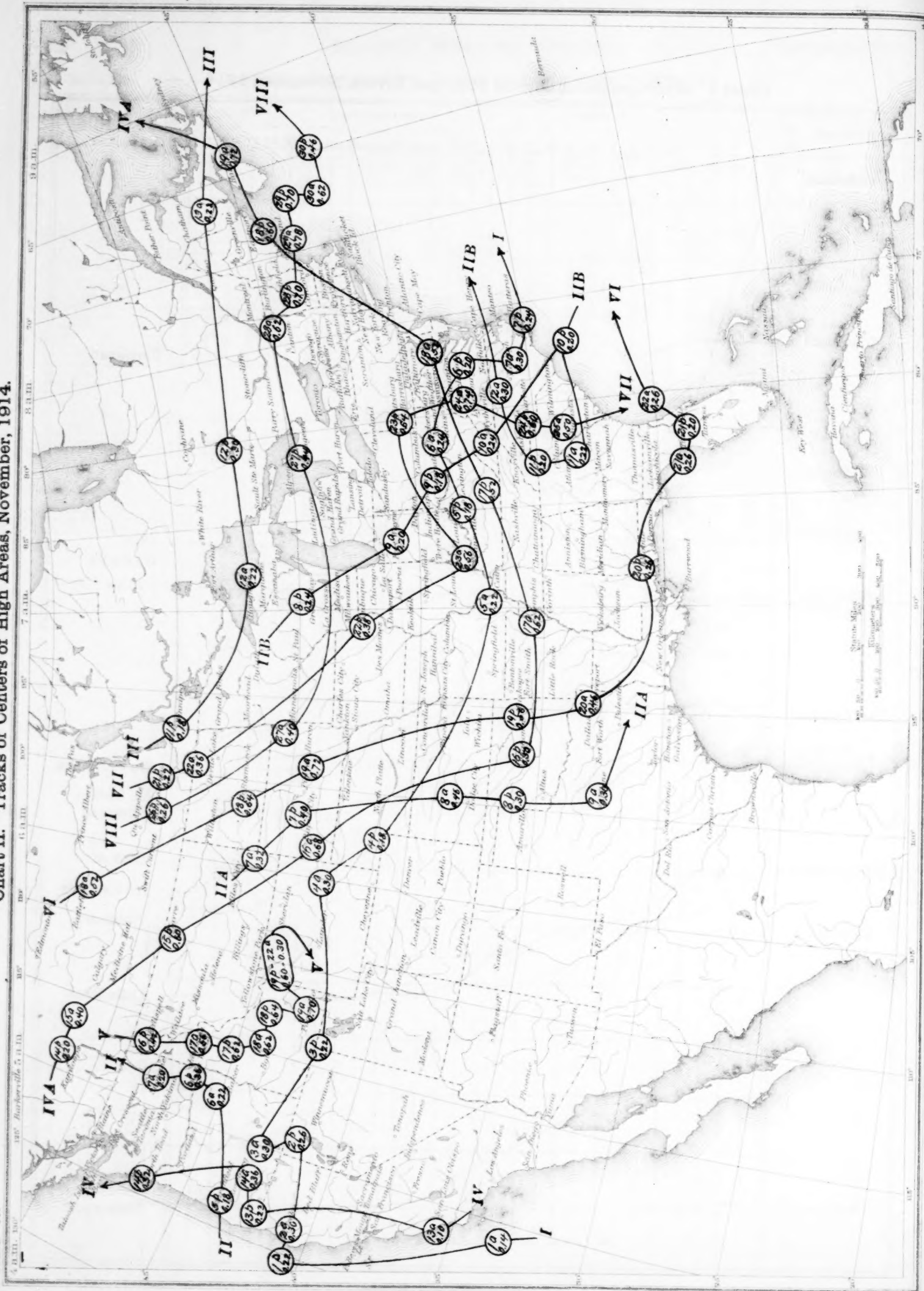
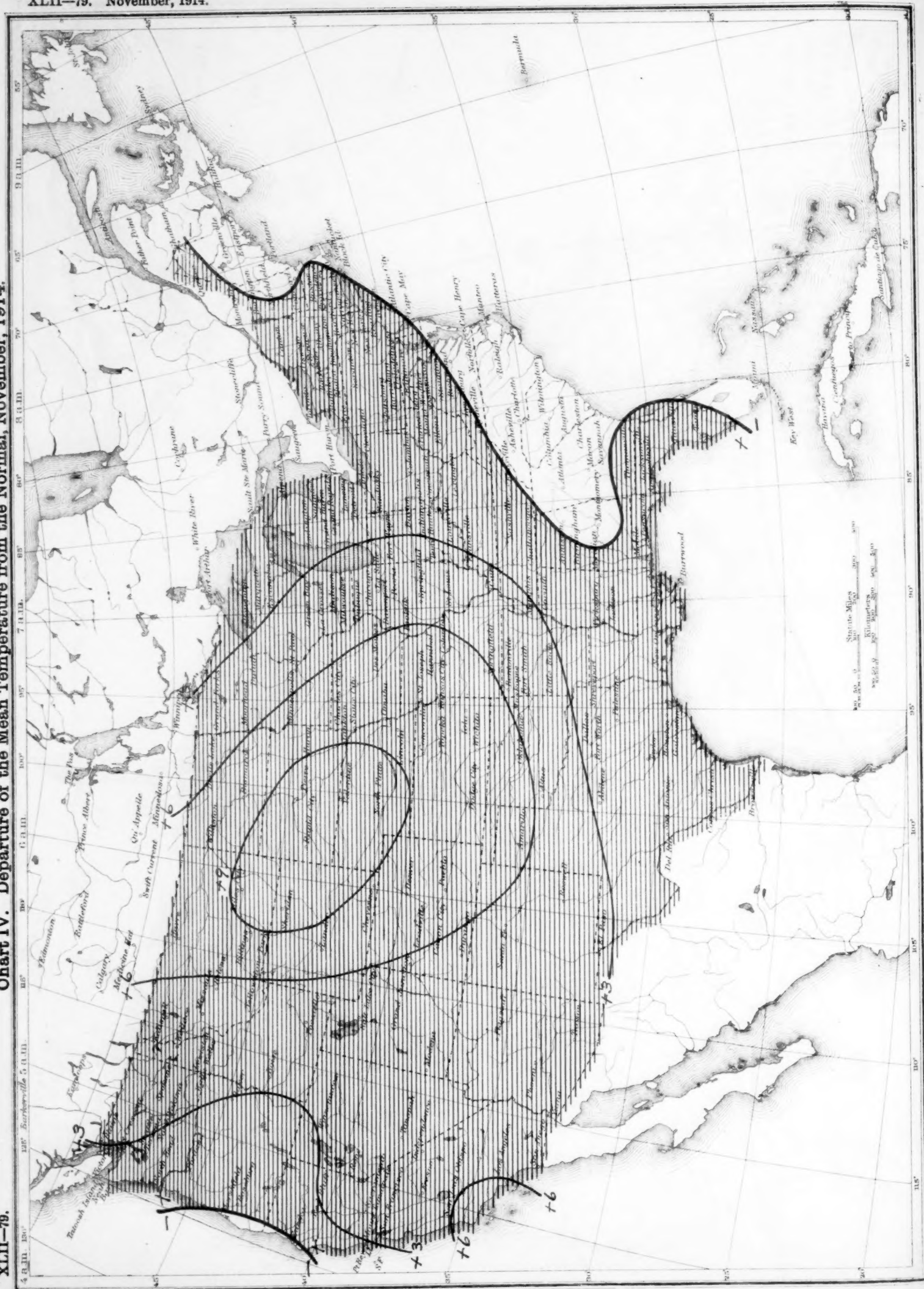


Chart III. Tracks of Centers of Low Areas, November, 1914.



Chart IV. Departure of the Mean Temperature from the Normal, November, 1914.



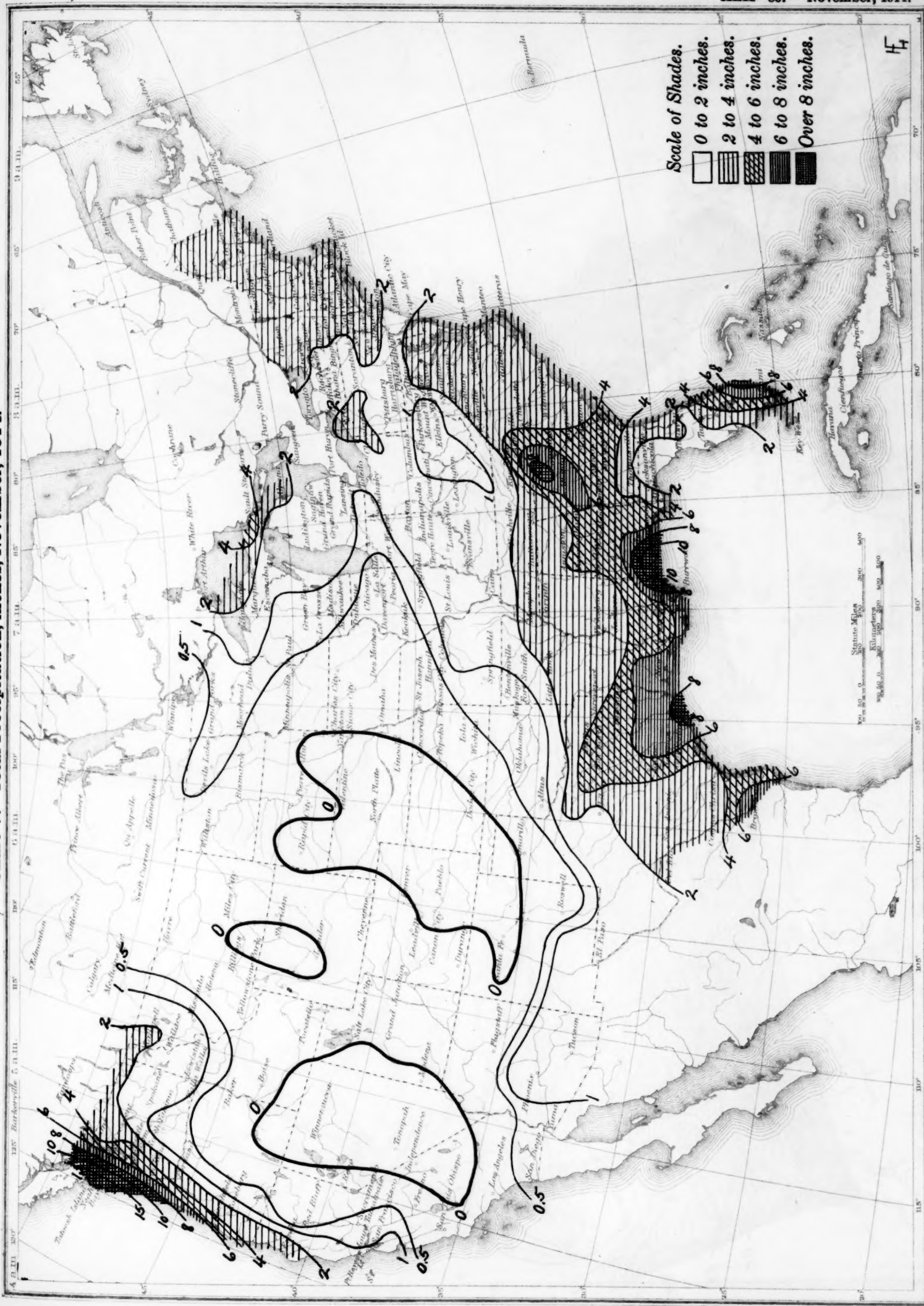
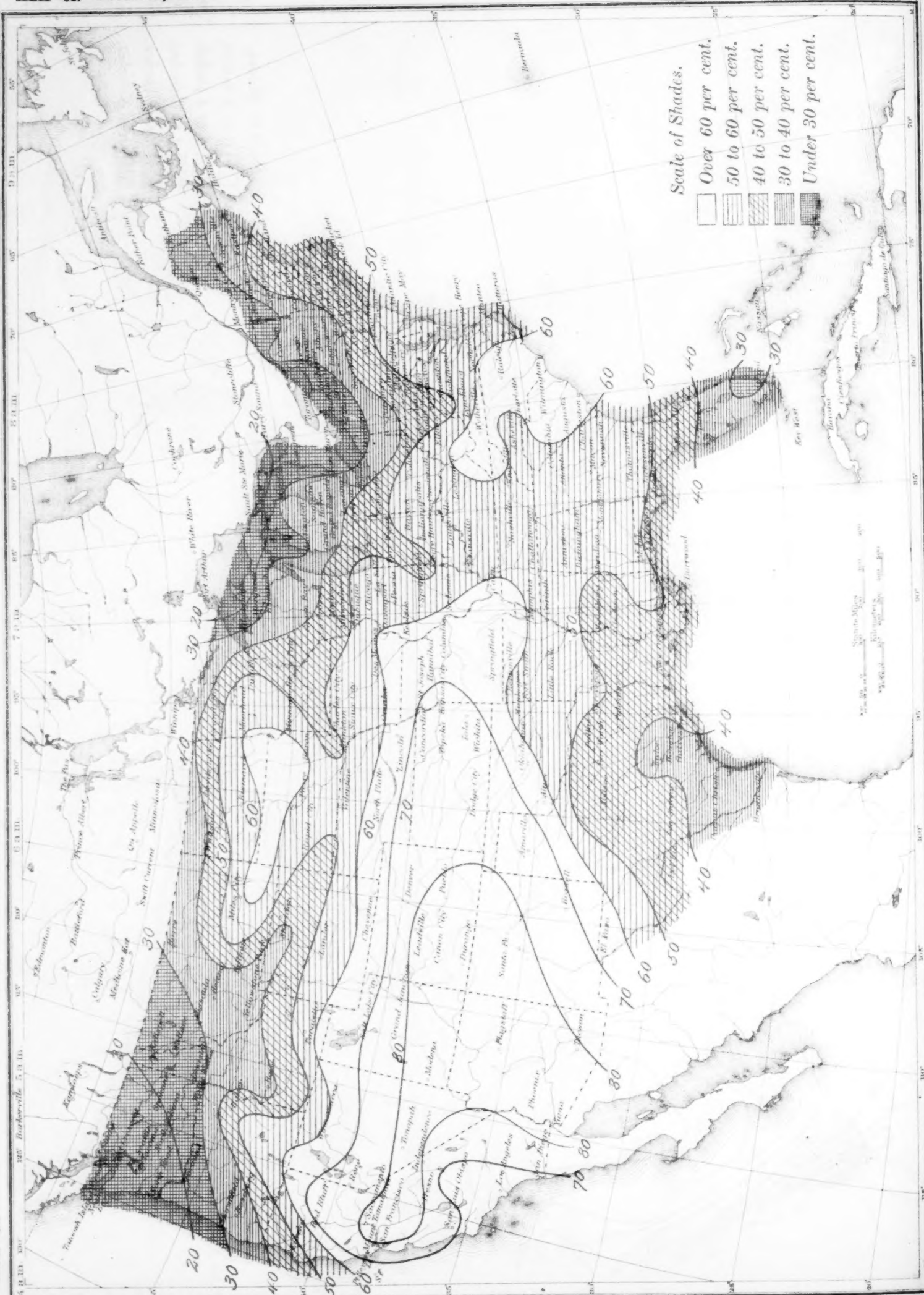







Chart VI. Percentage of Clear Sky between Sunrise and Sunset, November, 1914.



Scale of Shades.

	Over 60 per cent.
	50 to 60 per cent.
	40 to 50 per cent.
	30 to 40 per cent.
	Under 30 per cent.

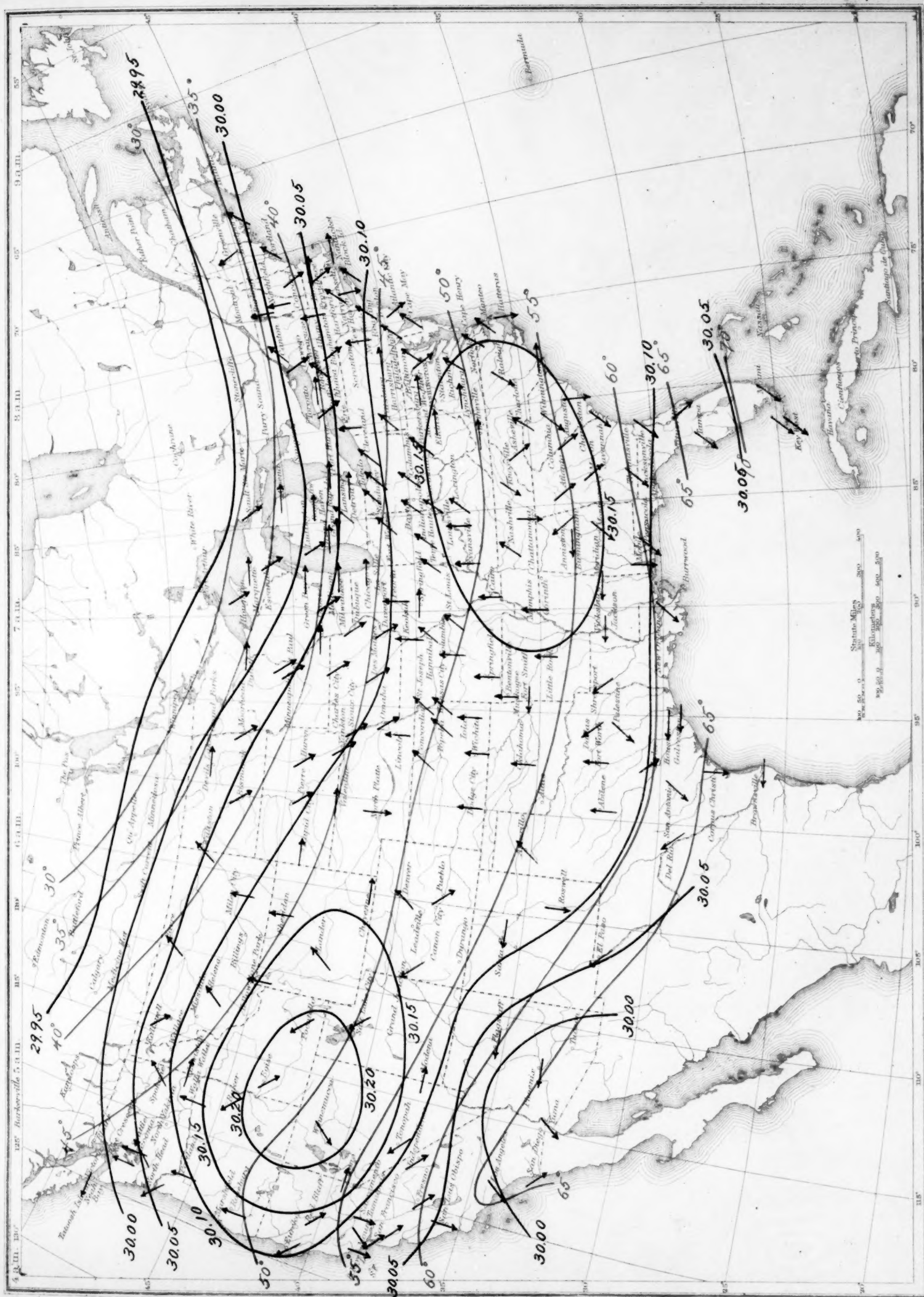


Chart VIII. Total Snowfall, inches, November, 1914.

